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STRATIGRAPHY OF TERTIARY ROCKS BETWEEN TORQUAY AND EASTERN VIEW, VICTORIA

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Purpose and Scope of Investigation

For many years one of us (I.C.) has been examining the micro-faunas of the Tertiary beds of East Gippsland. In this region a considerable number of bores, and a shaft 10 ft. in diameter and 1,214 ft. deep, have provided samples through the complete local Tertiary sequence. As a result certain criteria for recognizing the sub-divisions of the Tertiary have been established, based on the micro-fauna (Crespin, 1941, 1943). The primary objective of the investigation described in this paper was to compare the faunas of the Tertiary of East Gippsland with those of the type sections of the "Anglesean" and "Janjukian" Stages (Hall and Pritchard, 1902, Singleton, 1941). Almost immediately the investigation commenced, however, it was found that the desired result could be achieved only by a detailed examination of the stratigraphy of the beds at the type localities for these Stages.

Casual examination and partial sampling of the Anglesea section revealed a considerable thickness of *Cyclammina*-bearing beds, where the late Dr. F. A. Singleton (1941, p. 25) had reported "unfossiliferous white sands". Examination of the section north of Point Addis and between Point Addis and Rocky Point showed that the relationship of the "Anglesean" to the "Janjukian" was revealed in outcrop and that errors had been made in correlating the beds exposed in different parts of the cliff sections between Rocky Point and Torquay. Sampling of the beds included in the uppermost "Janjukian" at Point Addis indicated a foraminiferal content more closely related to the "Balcombian" than to the "Janjukian". It was concluded that systematic measuring and sampling of the coastal sections between Torquay and Eastern View would enable the "Anglesean" and "Janjukian" to be adequately described (and perhaps re-defined) and their relationship to each other determined, and that it would also provide an opportunity to prepare a list of foraminifera in those units at the type localities.

Accordingly, every accessible exposure on the cliffs in these localities was examined, selected sections were measured and sampled, and the foraminifera in them identified. Correlation between the sections was made as carefully as the conditions permitted. In some places, as notably from Bird Rock westwards, several distinct markers were identified, enabling good control of correlation to be maintained.

During the investigation, cliff sections were examined from Point Danger to Eastern View, a straight-line distance of 18½ miles; 22 sections were measured and sampled in detail. Continuous sampling cuts were made through the measured sections in the same way as in sampling an orebody. Approximately 200 samples were examined for foraminifera and a complete list of species contained in each sample was compiled. As far as possible, sections were measured and sampled in continuous sequence directly through the true thickness of the section. In some places, however, it was necessary to compile the section by a series of stepped offsets. As almost all sections measured are cliff exposures, the errors introduced through imperfect observation of dip and calculation of true thickness from outcrop width are few.

As originally planned, publication of the detailed results of this work was not intended. When it became apparent that there were serious errors in the published accounts of the geology of the area, discussions with other workers in the area—notably F. A. Singleton—were clearly desirable. Unfortunately, Singleton died before this discussion could take place. In 1951, when this work was nearly completed, the authors learned that Dr. Owen Singleton, F. Colliver, A. C. Frostick, A. C. Collins and the late W. J. Parr, had a paper in preparation on the area. The authors, therefore, decided to defer publication of their work. After waiting for a year, however, they decided to publish a summary of their results (Raggatt and Crespin, 1952) and they now consider it desirable that a more comprehensive paper should be published. It is to be hoped, however, that the results of the investigation by Owen Singleton and his collaborators will not be lost, particularly in so far as it deals with the shelly fossils, to which only passing reference is made in this paper.

Geographical Names

There are many natural features on the Torquay-Eastern View coast that have not been named. This is not uncommon in Australia, but it is curious that on a coast so near to and so accessible from the cities of Melbourne and Geelong the beaches and headlands of this coast should have gone so long unnamed.

Named natural features are essential not only for general descriptive purposes but for the naming of stratigraphic units. The notes hereunder refer to features that are named for the first time in this paper and to those features concerning which there can be no misunderstanding. The names listed have been submitted to and approved by the Surveyor-General of Victoria. Place names mentioned in the text are shown in Fig. 1.

Addiscot Beach

Name proposed for the beach which extends westerly from the south-west side of Bell's Headland. The name is taken from the name of the property—Addiscot—shown on the military one mile sheet—Anglesea—one mile to the north of the beach.

Bell's Headland

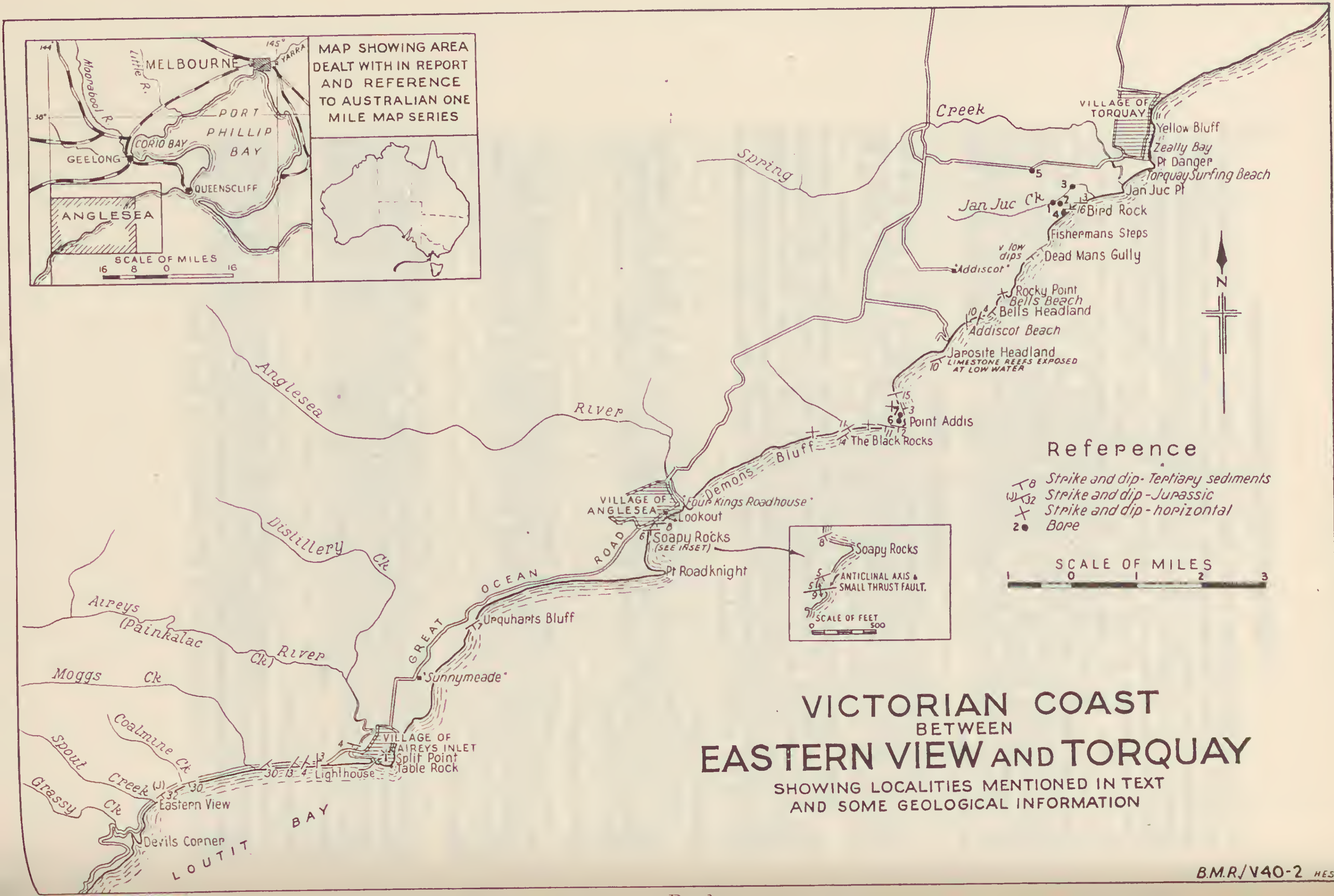
Name proposed for the bold limestone headland at the western end of Bell's Beach. The name is derived from that of the original holder—William Bell—of Portion 19, Parish of Jan Juc, which adjoins the headland. Bell's Beach is shown on the Anglesea military sheet.

Bird Rock

This name has been used (but has appeared only on geological maps) by geologists for many years for the small rock stack about one mile westerly from the mouth of Spring Creek (shown on Lands Department and military maps). The stack is at the western end of the beach (unnamed) at which Jan Juc Creek enters the sea. The steep cliffs adjacent to the stack are known as Bird Rock Bluff (Singleton, 1941).

Fisherman's Steps

Well known to geologists, fishermen and holiday makers, but not named on maps. The steps were originally cut out of the rocks that form the cliffs at this point (Tate and Dennant, 1895, p. 118) but were replaced by wooden steps many years ago. The steps are half a mile south-west of Bird Rock.



VICTORIAN COAST
BETWEEN
EASTERN VIEW AND TORQUAY
SHOWING LOCALITIES MENTIONED IN TEXT
AND SOME GEOLOGICAL INFORMATION

Reference
- Strike and dip - Tertiary sediments
- Strike and dip - Jurassic
- Strike and dip - horizontal
- Bore

Jarosite Headland

Name proposed for the headland between Point Addis and Bell's Headland, one mile north-east of Point Addis. It is named after the mineral jarosite which occurs in the cliffs and was once collected and calcined for the production of a red pigment.

Rocky Point

From the earliest times this name has been used for the headland at the eastern end of Bell's Beach, three miles south-west of the village of Torquay (e.g. Tate and Dennant, 1893). The military one mile map (Anglesea) issued in 1921 shows Rocky Point as the headland on the southern side of the mouth of Spring Creek. This point, however, is named Jan Juc or Jan Juk on old plans in the Victorian Department of Lands. The Surveyor-General of Victoria agrees that the oldest use of the name Rocky Point should stand.

The Black Rocks

Name of first point west of Point Addis shown on the Anglesea military sheet as Black Rock. "Black Rock" is a common name around Port Phillip and adjacent areas. Retention of the definite article and the plural will help to distinguish this point from others similarly named. The local people refer to the locality as *The* Black Rocks.

Yellow Bluff

Shown on Singleton's map (1941, Fig. 7) at the northern end of Zeally Bay.

Zeally Bay

Shown on Singleton's map (1941, Fig. 7) as the bay on the northern side of Point Danger. The Zeally family were the original settlers at Torquay. It was they perhaps who named the place Puebla. "Puebla" has been superseded by "Torquay" as the name of the village, but it has been retained for the name of the parish. Point Danger is shown on old Admiralty charts as Zealy Point (spelt with one "l").

Previous Investigations and Conclusions

Since 1863, when Daintree wrote, "On the coast from Jan Juc Creek to Point Addis these . . . beds are seen in splendid cliff sections", a great deal of attention has been paid to this locality.

Daintree (1863) first referred to the sections between Bird Rock and Jan Juc Creek as consisting of two major lithological units but in the marginal note to the Victorian Geological Survey Quarter Sheet 28.S.E. and in the version of the report published in 1898 he recognized three units:

*Upper	80 ft.	Sandy limestone.
*Middle	110 ft.	Brown blue and yellow sandy clay; gypsum abundant in lower 30 ft.
	1 ft.	Hard crystalline sandstone.
	23 ft.	Sandstone and marl with pyrite.
*Lower	1 ft.	Very hard band of crystalline sandstone.
	45 ft.	Sandstone.

Daintree also referred to the "cliffs of sands black with carbonaceous matter" but did not discuss their relationship to the other sediments.

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*Not used by Daintree and added here merely to facilitate discussion.

Tate and Dennant (1893, 1895) rejected Daintree's threefold subdivision because they thought the upper limestone was a facies of Daintree's middle beds. Hall and Pritchard (1896) agreed with Tate and Dennant. However, there is no doubt Daintree's subdivision is right in principle, though wrong in detail (see full discussion, pp. 100-101).

Some remarks made by Tate and Dennant in their 1895 paper are relevant to this investigation. They point out (pp. 120-121) that "fallen blocks from the upper levels strew the beach and hitherto collectors have mixed indiscriminately the fossils yielded by them with those gathered *in situ,* the theory being that the fauna was practically indivisible. . . . we offer the suggestion that . . . above the echinoderm-rock (Jan Juc formation of this paper, H.G.R. and I.C.) a minor zone of the Eocene may possibly be demonstrated . . . at any rate the matter is worthy of further research."

In 1902, Hall and Pritchard set out certain principles which they considered should determine the naming of the subdivisions of the Victorian Tertiary:

"As a great amount of work for many years to come will be concerned with the local correlation of our beds, and the elaboration of our sub-divisions, it seems to us advisable to employ local names for the main sub-divisions of our strata. This plan is of world-wide use, and by its adoption we should be making no retrograde step, but would be clearing the way for a detailed consideration of two problems, namely the correlation of our strata between themselves and the correlation with strata elsewhere. If the main types have these names applied to them there will no longer be any need to say whose views one is following, as we need to now, when speaking of certain beds as Eocene or Miocene. The important question as to the relative position of the different formations can be put on one side and need not be forced into consideration in every line of a paper dealing with some small local set of strata.

"Recognizing then the advisability of such a change, it remains to consider what are the principles which should actuate us in our choice. These seem to be few and simple. Firstly, any series of strata with a fauna differing appreciably in its constituents from others should receive a distinctive name. Secondly, the name should be taken from a locality where there is no chance of confusion between the contents of beds of distinct ages. Thirdly, we should not use the names which are used in other parts of the world as names of formations. In the fourth place, it should be understood that the names given are given to a particular set of strata and are irrespective of the correctness or otherwise of the subsequent correlation of other beds with them."

On this basis Hall and Pritchard defined the Balcombian and the Jan Jucian in the following terms:

Balcombian: "The clays and limestones of Balcombe's Bay contain another distinct fauna. The beds are sometimes spoken of as Mornington, but the locality we give is more exact. The Lower Beds at Muddy Creek and the Orphanage Hill beds at Fyansford, near Geelong, are approximately equivalent to the Balcombe's Bay beds, but the exact separation of the two sets of beds at Muddy Creek is not yet sufficiently clear, and a name from that locality would lead to confusion. The beds are called Eocene by Messrs. Tate and Dennant and ourselves. Sir F. McCoy considered them Oligocene."

*Jan Jucian**: "The section near Spring Creek, on the coast of Bass Strait, south of Geelong, is in the main in the Parish of Jan Juc, and its fauna differs greatly from that of Balcombe's Bay. The confusion about the age of these beds has been referred to above. The township near Spring Creek is called Torquay, but the use of this name in England renders another advisable. The older name for Torquay was Puebla, but the employment of this name, again, would lead to confusion with certain American strata. The name Jan Juc remains, and is referred to by McCoy as the locality whence several of his fossils came."

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*Later the spelling Janjukian was used.

The section at Balcombe's Bay is not dealt with in this paper, but as Hall and Pritchard define it, the Janjukian can scarcely be discussed without reference to the Balcombian.

Having defined their units, Hall and Pritchard add the following comment:

"We should like once more to emphasize the point that the names we give are given in the first place to the beds displayed at the localities from which the names are derived, and we are thus able to fix a top and a bottom to each formation. There can be no doubt, except in our opinion in the case of Aldingan and Jan Jucian, of the distinctness of the faunas they typify."

The status, in terms of modern concepts, of units thus defined is somewhat dubious. The first criteria suggested—difference of faunas—is unreliable in a region where facies changes are common and difficult to trace because good exposures are widely separated. It is unfortunately not true that in the sections nominated as types for the Janjukian and the Balcombian "a top and a bottom" can be fixed.

It is not surprising that confusion resulted, that different opinions have been expressed as to the relative stratigraphic position of the Balcombian and Janjukian, and that the term "Barwonian" (Hall and Pritchard, 1904, pp. 297-8) was suggested to include beds with faunas not clearly referable to either Balcombian or Janjukian.

In 1910 Hall gave a good generalized description of the sections exposed between Torquay and Eastern View. He made reference to several of the features described in this paper and his contributions will be noted in their proper place. At this point, however, attention is directed to the fact that although in this paper Hall, by use of the following phrase, clearly recognized the relationship of the limestone of Rocky Point to the black sandy clays—"the fossiliferous yellow limestone of Rocky Point . . . on rounding a small point [Bell's Headland.—H.G.R.] is seen to overlie purple and black sandy clays . . .",—he not only considered the fossiliferous black beds at Anglesea as a marine phase of the coal measures at Eastern View but apparently he regarded the beds in the lower part of the Bird Rock section as a facies of the "purple and black sandy clays". He wrote: "as we go north-east along the coast [from near Airey's Inlet.—H.G.R.] the influence of marine conditions is more strongly felt and near Anglesea marine fossils . . . are sparingly found. Still farther on the character of the beds beneath the yellow limestone changes; gravels and grits disappear and at Rocky Point marine fossils of all kinds are common, the beds becoming richer as we approach Bird Rock."

The first statement quoted above seems to have been overlooked by later investigators. It refers to the only known section showing a passage from the black sandy clays to the overlying marls and limestones and examination of it would have saved much of the fruitless discussion which has taken place on the relationship of the "Janjukian" to the "Anglesean".

In the absence of a precise definition of "Janjukian" either as a rock or time-rock unit, the term was extended to include beds proved by boring below those exposed in the type locality. A bore which was put down to a depth of 70 ft.

between Bird Rock and Fisherman's Steps (i.e. immediately below the lowest beds of the type section) was reported upon by Chapman (1922a) in the following terms:

> "The foregoing results of an examination of the detailed structure and contents of the Torquay boring prove that down to 70 ft. the strata are still in the Janjukian series.
>
> "The fact that green sands and marls with a Janjukian fauna prevail throughout, points to a downward extension of the lower beds of the Bird Rock Cliffs, at least 70 ft. below the level of the boring at the surface.
>
> "Judging by the sections in the Mallee bores and in South Australia, there should come below these green sandy marls a series of estuarine and brackish water beds, as are indeed found at Anglesea and elsewhere along the Otway coast.
>
> "Such restricted fossils as *Mopsea hamiltonensis, Venus* (*Chione*) *halli,* and *Volvula inflatior,* point to the Janjukian age of these lower strata with certitude; whilst a numerous fauna, which, although not restricted, is more typical of Jan Jucian beds, is well represented in this series. Amongst the latter are: *Carpenteria proteiformis,* var. *plecte, Turritella gemmulata, Marginella kitsoni* and *Mangilia sandleroides.*" (The log of this bore is given on p. 196.)

In 1925 Pritchard himself, writing about the Janjukian, stated that "the total thickness as measured on the cliff faces from the south of Spring Creek to the centre of the Bird Rock Dome is about 183 feet, but the actual thickness of this marine series is rather more than 1,000 ft."

Chapman and Singleton (1925) stated that greensands and marls similar to those proved by the 70 ft. bore reported upon by Chapman (1922a) had been proved by later boring to a depth of 170 ft. below sea level. (The beds thus referred to, however, are stratigraphically higher than those penetrated by the 70 ft. bore; see discussion, pp. 114, 121, and Fig. 4.) In this paper (p. 997) they wrote:

> "In Victoria this series (Janjukian) is represented by the lignitiferous beds with *Cyclammina* found in depth in the Torquay bores and outcropping farther along the coast in the high cliffs between Point Addis and Anglesea."

This statement cannot be reconciled with Chapman's earlier (1922a) remarks quoted above unless in the intervening time it is assumed that he came to accept the views expressed by Pritchard in 1925.

In 1941* Singleton re-defined the Janjukian as a time unit in the following terms:

> "The Janjukian may be defined as the interval of time represented by the deposition of the marine beds outcropping in the coastal sections, about three miles in length, between Rocky Point and the mouth of Spring Creek, in the Parish of Jan Juc, and proved in borings to a depth of 170 ft. below sea level, as well as those represented therein by non-deposition or erosion."

This definition, like the earlier one of Hall and Pritchard, is open to the objection that it refers to an interval of time represented by a partial sequence. The base of the sections is not related to any formational contact and no criterion is suggested by which it may be recognized; the upper limit is a modern erosion surface. As mentioned above and discussed later (p. 121) the beds "proved in borings to a depth of 170 ft." are above those proved by the 70 ft. bore described by Chapman (1922a).

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*So far as Tertiary stratigraphy is concerned, and especially that of the coastal sections described in this paper, Singleton gave only the barest outline of his conclusions in his 1941 paper. Singleton had a unique knowledge of the Australian Tertiary shelly faunas, and it is a matter for great regret that he died before much of his work was ready for publication. However, it is his published work that is quoted, and it is unavoidable that errors therein should be indicated.

Singleton (1941) put forward the name "Anglesean" in the same dual sense as Hall and Pritchard proposed their names. Thus he defined it (p. 24) as "black sandstone and sandy clays . . ." at Anglesea and (p. 25) as "the interval of time represented by the deposition of the dark-coloured sands with *Cyclammina* of the cliff sections between Anglesea and Point Addis, ..." At the time he proposed this name Singleton could have given only cursory consideration to the Anglesea section. He stated that "the upward limit of the Anglesean is given by the overlying unfossiliferous white sands", but the beds to which he refers as unfossiliferous differ little except in colour from those of the type "Anglesean". He discussed the relationship between the "Anglesean" and "Janjukian" and postulated the existence of a "Stage" between the two (p. 65). Owen Singleton (F. A. Singleton's son) states, in a note written to E. S. Hills, that his father had found evidence proving that the "Junjukian" rested conformably on the "Anglesean". As stated on page 81 Hall had directed attention to the section showing this relationship, in 1910.

Description of Sections

In this part of the paper a description of each section that was measured and sampled is given, together with a list of the foraminifera contained in the samples. Brief notes are included giving the geographical and approximate stratigraphical relationship of the sections to each other.

In the next part of the paper reference is made to the sections described in this part and they are placed in their correct stratigraphic position. It is hoped that this arrangement of the subject matter will facilitate recognition of localities and beds from which fossil collections have been made.

The sections are described in this sequence: Anglesea; Anglesea to Rocky Point; Bird Rock; Bird Rock to near Rocky Point; Bird Rock to Torquay; westward from Anglesea to Eastern View.

Anglesea River to Demon's Bluff

Singleton's type section for the "Anglesean" (see his Plate 1, Fig. 1, 1941) is about midway between the mouth of the Anglesea River and the Demon's Bluff Trig. Station. Examination of the section shows that it consists of two main lithological types. The lower part of the cliffs consists of clayey carbonaceous siltstone which are dark brownish grey (SYR3/1)* on exposed surfaces but a brownish black (SYR2/1) when freshly broken. The upper beds are fine quartz-clay greywacke. At and near their base they are pale red purple in colour; the colour intensity of the beds decreases upwards (from SRP6/2 to SRP5/2). The highest are yellowish. The rocks here designated siltstone and greywacke are not markedly different in composition or grain size, and it is possible that a more detailed examination might not support the use of the lithological names that have been adopted. (Glover, 1954; Dallwitz, 1954.)

However, as the rocks are different in appearance it is useful to differentiate between them. The section described hereunder was measured and sampled at the type locality. The sequence is in descending order.

*Refers to colour chart prepared and issued by the Rock-Colour Chart Committee, U.S. Geological Survey.

Section 1

Sample No.	Thickness (ft.)	Description
E.17	4	Fine quartz-clay greywacke; some organic matter in lowest beds but less and less upwards; *Cyclammina* common; particularly abundant in lower 10 ft. Bedding planes poorly preserved, but cross-bedding marked by ochreous concretionary nodules.
E.16	7	
E.15	6	
E.14	5	
E.13	5	
E.12	5	
E.11	5	
E.10	4	Pale red-purple fine quartz-clay greywacke; *Cyclammina* especially abundant in lower 10 ft.; generally otherwise like lower siltstones including abundance of worm burrows and "algal" remains.
E.9	5	
E.8	5	
E.7	5	
E.1	11	Clayey carbonaceous siltstone with abundant white worm burrow fillings and "algal" remains. *Cyclammina* common at top, but rare in lower part. Rock structureless in hand specimen, but bedding planes identifiable in cliff. Upper surface eroded in places.
E.2	7	
E.3	7	
E.4	7	
E.5	11·5	
E.6	5	
E.1-E.17	104·5	

The beds E.1-E.6, 48·5 ft. thick, correspond to Singleton's "41 feet of black sandstone"; the beds E.7-E.17, 56 ft. thick, correspond to his "47 feet of unfossiliferous white sands". Part of this section is illustrated in Pl. IV, Fig. 3.

In the cliffs at Demon's Bluff, 2 ft. above the contact of the siltstone and the greywacke, lenses up to 2 ft. thick occur which, in colour and lithology, are indistinguishable from the siltstone.

The siltstone, wherever seen, has the same lithology and is marked by closely spaced nearly vertical jointing. On the walls of the joints it is not uncommon to find radial markings. The easiest way to give a mental picture of the markings is to liken them to a lady's fan (but circular) open almost to its full extent. The commonest diameters noted are nine inches to two feet. It is considered most probable that these markings were formed as part of the process of development of tension joints (Woodworth, 1897). The tension joint markings apparently have not been noted previously, but Hall (1910) remarked—"the chief peculiarity of the black series is its jointing . . . great sheets flake off the vertical cliffs and fall or hang in threatening positions nearly 100 feet above the beach".

The distribution of foraminifera in the samples from Section 1 is shown in Table I. The samples are arranged in ascending sequence.

Anglesea River to Point Roadknight

A section with many features in common with that described above is exposed west of the Anglesea River. Much of the section can be viewed from the lookout on the Great Ocean Road at the top of the hill south-west of Four Kings Roadhouse. The photograph, Pl. IV, Fig. 2, is taken from this viewpoint.

The disconformity noted on the eastern side of the river between the siltstone and the greywacke is much more marked on the western side. The section hereunder illustrates this.

The siltstones closely resemble the beds E.1-E.6 and the beds 30 ft. thick below the "marked bedding plane" shown on the section are very much like E.7-E.10.

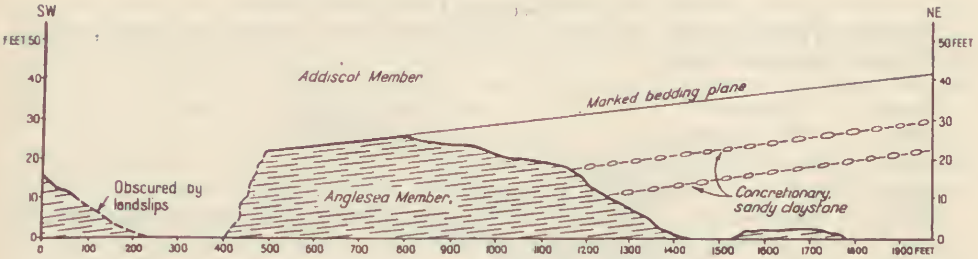
SW
NE
FEET 50
40
30
20
10
0
50 FEET
40
30
20
10
0
Addiscot Member
Marked bedding plane
Obscured by landslips
Anglesea Member
Concretionary, sandy claystone
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 FEET

FIG. 2.—Section at Anglesea showing disconformable contact of Addiscot and Anglesea Members.

This 30 ft. interval, however, includes two thin concretionary sandy claystone beds, with abundant *Cyclammina,* which end sharply against the erosion surface as indicated in the above Fig. 2. Because of this general similarity between the sections and because *Cyclammina* is readily identifiable in hand specimens, sampling at this point was restricted to a limited interval, below and above the disconformity, with the object of seeing whether there was a faunal change related to the erosion surface. The partial section described below was measured at the locality of Fig. 2.

SECTION 2

Sample No.	Thickness (ft.)	Description
—	0 - 0·5	Off-white, concretionary, sandy claystone.
W.3	5·5	Pale red-purple greywacke (cf. E.7-E.10).
W.2	10·0	
		Erosion surface.
W.1	3·0	Brownish black clayey siltstone (cf. E.1-E.6).
—	—	Beach.

The distribution of foraminifera in the samples from Section 2 is shown in Table II. The samples are arranged in ascending sequence.

Commencing at the top of the siltstone a continuous section was measured from a point about 200 ft. west of a point vertically below the lookout, through Soapy Rocks to the boat harbour inside Point Roadknight. Details of this section are given in Section 3.

The following details will enable the several units in the section to be recognized in the field (see Pl. IV, Fig. 2):

W.4 to W.12—Continuous cliff exposure from starting point of section southerly to end of beach (at high tide) at Soapy Rocks. W.12 is easily identified by its yellowish-green efflorescence.

W.98 and W.99—Soapy Rocks. (Breccia, agglomerate and ripple-marked tuffaceous sandstone are easily identified.)

W.100—Small cove on south side of Soapy Rocks readily identified by small anticline and overthrust fault.

W.101 and W.106—W.101 forms small headland at high tide. South of this the boat harbour beach extends without interruption to Point Roadknight. W.106 and overlying white clay are clearly exposed on top of W.101.

SECTION 3

W.105—The clays and sandstone form cliffs at the back of the northern end of the boat harbour beach.

Sample No.	Thickness ft.	in.	Description
—	–	–	Surface.
W.105	–	–	Top 6 ft. of W.102.
W.102	30+	0	Red, brown and yellow claystone, irregularly interbedded with fine brown sandstone.
W.—	0	2-8	Light grey clay.
W.106	0	4/18	Volcanic conglomerate with pebbles up to 2½ in. diameter. Passes into brown sand (mixture of quartz and coprolites) with pebbles of basalt up to 2½ in. diameter.
W.101	15	0	Fine, thinly cross-bedded sandstone; yellow at outcrop.
W.100	6	0	Finely laminated silty sandstone grading downwards into sandy mudstone; 2 in. carbonaceous layers. In places lower 4 in. shows "worm-track" lithology.
W.100a	–	–	Lower 6 in. of W.100.
W.99	4/6	0	Clayey volcanic agglomerate including 9 in. laminated tuffaceous sandstone at top; upper surface ripple-marked.
W.98	6/12	0	Shale-volcanic breccia.*
W.12	1	6	Shale.
	0	9	Shale with jarosite efflorescence.
	0	9	Shale.
	0	2	Brown coal.
W.11	9	0	Grey fine greywacke. Sharp change in lithology above this bed.
W.10	12	0	Grey fine greywacke.
W.9	12		2 ft. pale red-purple clayey greywacke with worm burrows. 4 ft. pale red-purple greywacke with thin shale partings.—Layer of quartz pebbles up to ½ in. diam. 6 ft. Same as top 2 ft.
W.8	11		Pale red-purple greywacke. *Cyclammina* abundant in groups.
W.7	10		Pale red-purple greywacke with worm burrows; *Cyclammina* common in groups.
W.6	3		Pale red-purple greywacke.
W.5	11		Pale red-purple greywacke with some thin brownish-black bands in lower half; top weathered deep red; worm burrows.
W.4	5		Cf. W.5; 6 in. dark band at top.
Erosion surface			
–	–		Brownish-black *Cyclammina*-bearing clayey siltstone.

*Identified also by Hall (1910) who records thickness as 12 ft.

This section is made up of three, perhaps four, units in descending sequence:

Sample No.	Thickness (ft.)	Description
W.102	30	Clays and sandstone poorly bedded and probably in part tuffaceous. Laid down in fresh water.
W.12-W.106	39	Well bedded fluviatile sediments and some volcanic material.
W.4-W.11	73	Greywacke containing much organic matter probably deposited under estuarine conditions after slight uplift and erosion of unit below.
—	—	Similar to unit above but finer grained and containing more organic matter.

Cyclammina is so abundant and easily identified in the two lower units as to be a lithological characteristic.

The ferruginous coarse sandstone to conglomerate (white quartz pebbles commonly ¼ to 1 in.; some 3 in. diameter) from which is derived the pile of rocks on the beach at the eastern end of the cliffs below the lookout, is lenticular and does not occur where the foregoing section was measured. Its base is 12 ft. above the base of W.4 and its maximum thickness is 12 ft.

There is no doubt that the siltstone and overlying greywacke, both with *Cyclammina,* on either side of the Anglesea River, are parts of the same formation and that the beds represented by W.12 and W.102 on the west side of the river are stratigraphically higher than any bed exposed on the east side of the river.

The distribution of foraminifera in the samples from Section 3 is shown in Table III. The samples are arranged in ascending sequence.

The higher beds are unfossiliferous.

Demon's Bluff to The Black Rocks

The apparent anticlinal structure between Anglesea River and The Black Rocks has been explained in two ways—by Singleton (1941) as an anticline, and by Hall (1910) as a weathering effect.

Referring to this and other sections, Hall (1910) has suggested that the gradation in colour of these beds from nearly black through dark brown to pale purple is a function of Recent to Sub-Recent weathering, but this is clearly incorrect. As stated earlier in this paper, the contact between the dark- and light-coloured beds in places is marked by a contemporaneous erosion surface and there are small dark-coloured lenses interbedded with the light. The colour differences are, therefore, an original condition of the sediments; it is true, however, that the darkness of the lower beds is accentuated in places by their being continually moist with sea spray.

On the western side of the Anglesea River the beds dip 8° on a bearing of 165° and at The Black Rocks 12° on a bearing of 133°. There is, therefore, a possibility that the beds are part of an anticline plunging south-westerly. The apparent anticlinal structure is accentuated by the fact that the beds are exposed on a curving cliff front which, in plan, is concave facing the direction of dip.

From Demon's Bluff to The Black Rocks the same beds as those described at Anglesea are well exposed and there is an excellent, easily accessible cliff section showing the contact of the carbonaceous siltstone and the greywacke on the western side of The Black Rocks (see Pl. V, Fig. 1). At this locality the two units are conformable. There is a great abundance of *Cyclammina* in the greywacke. The Black Rocks themselves are formed by a pebbly sandstone with ferruginous cement. Its base is 33 ft. above the top of the carbonaceous siltstone and it locally attains a thickness of 40 ft.

The Black Rocks to Point Addis

It is clear that part at least of the uppermost freshwater beds exposed on the west side of the Anglesea River are present between The Black Rocks and Point Addis, but the beds are so disturbed by slumping that the section cannot be measured. Several samples were collected and examined for foraminifera, but none were found.

Point Addis

Point Addis is a prominent headland composed mainly of calcarenite overlain by marls and clays. The more massive beds forming the headland are somewhat irregularly bedded and it is therefore difficult to trace individual beds very far. From immediately north of Point Addis a beautiful curved beach extends for a mile to Jarosite Headland. The cliffs at the back of this beach are formed of beds closely resembling those at Anglesea.

SECTION 4
(Measured in descending order)

Sample No.	Thickness ft.	in.	Description	
PA.11	3	0	Cream to white friable calcarenite.*	
E.110-a	7	0	Cream marl.	
E.110-b	7	0	Fawn to pale yellow marly siltstone.	
E.110-c	7	0	Cream marl.	
E.110-d	9	0	Bryozoal sandy marl.	
P.A.10	12	0	Grey marly siltstone.	
PA.9	1	6	Calcarenite; friable, cream.	
	1	6	Calcarenite; tough, cream.	
	1	6	Calcarenite; friable, cream.	
	4	0	Calcarenite; tough, cream.	
PA.14	1	0	Calcarenite	cream to yellow.
	1	6	Siltstone	
	0	10	Calcarenite	
	3	0	Siltstone	
	1	0	Calcarenite	
PA.13	2	3	Silty marl	cream to yellow.
	0	6	Calcarenite	
	3	0	Silty marl	
PA.12	4	0	Calcarenite	
	5	6	Silty marl with small lenses of calcarenite; yellow.	
	0	2	Limestone conglomerate; pebbles commonly ½ in. to 1 in. and up to 1½ in.	
PA.7 and PA.8b	6	6	Calcarenite, cream to yellow (two samples of same bed at points 100 ft. apart; see sketch below).	
PA.15	10	6	Calcarenite, cream to yellow.	
PA.6	5	0	Brown gritty clay.	
PA.16	40	0	Chiefly grey and yellow sandy clay with some brown clayey sandstone. Exposure poor and incomplete.	
—	0	3/6	White and grey clay.	
E.112d	3	0	Grey clayey sandstone.	
PA.1	5	0	Brown and grey clayey sandstone with occasional quartz pebbles up to ½ in. diameter. *Cyclammina* abundant.	
PA.2	6	6	Grey sandstone with thin black lenses showing worm burrow lithology; *Cyclammina* abundant.	
PA.3	3	0	Like PA.2—blocky jointing.	
—	0	2/12	Quartz grit to quartz gravel bed.	
PA.4	8	0	Top 1 ft. like PA.3 but downwards lithology increasingly resembles that of upper beds E.7/E.17 of Section 1. Purplish tinge on weathered face.	
—	12	0	Same as lower part of PA.4.	
PA.5	5	0	As above, with some black lenses and layers of fine white sand. Abundant sand-filled worm burrows.	

*As indicated earlier in this paper, the work on which it is based was not undertaken in the first place with publication in mind; consequently insufficient attention was given to the lithology and composition of the sedimentary rocks. Comments on some of these are given by W. B. Dallwitz and J. E. Glover in this journal. These comments indicate that considerable care is necessary in the naming of the sedimentary rocks if they are to be classified correctly and differentiated from each other.

Particular attention is directed to the calcareous rocks in the cliff sections between Point Addis and Torquay, where alternations of beds resistant to erosion with beds that erode easily are common. Over the years a tendency has developed to use the words "hard" and "soft" instead of "tough" and "friable" to distinguish between these beds. The so-called "hard" rocks are in fact generally more calcareous than the "soft" ones; they resist weathering and erosion because of their finer grain size and cementation by calcium carbonate.

The beds PA.9 to PA.11 were measured continuously upwards from the top of the cliff at the extreme point of Point Addis. PA.12 to PA.14 were measured on the western side of the Point, i.e. at the eastern end of the beach between Point Addis and The Black Rocks. PA.7, PA.15 and PA.6 were measured north of the Point and from there round to the slumped outcrops where the outcrops of calcarenite end and the long curved beach begins. The beds in PA.16 were measured at low water in front of the slumped outcrops on the northern side of the Point; the beds from E.112d downwards are in continuous sequence on the north side of the slump. The limestone-conglomerate at the base of PA.12 marks a surface of contemporaneous erosion; it resembles closely the modern wave cut platforms in the limestone. The same surface can be identified at Bell's Headland.

The relationship between the beds represented by samples PA.7, PA.8b, PA.15 and PA.6 is best explained by a sketch (Fig. 3).

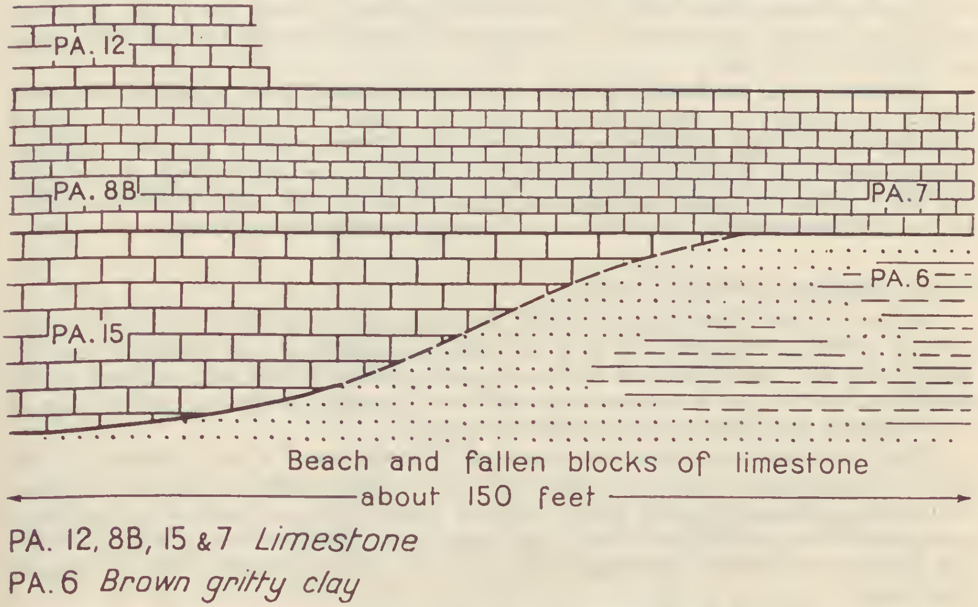

Fig. 3.—Sketch Section N.E. side of Point Addis.

The dark-coloured *Cyclammina*-bearing beds from E.112d downwards correspond to beds of similar lithology at Anglesea and The Black Rocks, but a more precise correlation is difficult to make. There is little doubt that broadly the beds represented by W.12 to W.105 in Section 3 can be correlated with E.112d to PA.6.

In 1923 (D.M., V., 1938, 17-18 and Plate 3) two bores were put down for oil at Point Addis. The bores were 822 and 842 ft. deep respectively and if the cuttings had been kept, or a log prepared at the time by a trained observer, information of considerable value would have been obtained, but only the driller's logs are available and these, despite the great variation in colour and lithology of the beds drilled, have only limited value for stratigraphical purposes. (See discussion p. 114.)

The distribution of foraminifera in samples from Section 4 is shown in Table IV. The samples are arranged in ascending sequence.

Jarosite Headland

The beds exposed between Point Addis and Jarosite Headland are the same as those which form Demon's Bluff. At Jarosite Headland, on both sides of the former haulage way from the beach to the site of the old jarosite treatment works, nearly vertical cliffs give a good section of the greywacke and siltstone represented in the sections at Anglesea. The peculiar worm burrow lithology is well shown; *Cyclammina* and pyritic concretions are common; marked, closely spaced, vertical jointing is well developed and on some of the joint surfaces the tension joint markings noted at Anglesea are preserved.

The cliff section was measured at its highest point. There are 80 ft. of pale red-purple greywacke and 35 ft. of brownish black siltstone at this point. Adjacent to the old jarosite haulage way a conformable contact between the two units may be examined with ease.

Off-shore from the headland there are three limestone reefs which are exposed and are accessible by wading at extreme low water. These beds dip 10° on a bearing of 145° and clinometer measurements indicate that if this dip is maintained toward the headland the limestones are above the highest beds exposed on the cliffs. Thus the limestone forming the reefs are in the same position relative to the *Cyclammina*-bearing beds as are the limestones at Point Addis.

Bell's Headland–Addiscot Beach

Bell's Headland is a prominent bluff formed predominantly of calcarenite overlain by siltstone and clay. On its south-west side, siltstone and marl are exposed underlying the calcarenite and beds still lower in the section are exposed at the mouth of, and on the south-west side of, a small gully on the south-west side of the headland (northern end of Addiscot Beach).

The dip of the beds on the south face of the headland is 4° on a bearing of 95° and on the south-west side of the gully 10° on a bearing of 80°. With the exception of a small gap where the gully meets Addiscot Beach, there are continuous exposures downwards through siltstone and clay, calcarenite, siltstone with shelly fossils to the *Cyclammina*-bearing greywacke and siltstone which form the cliffs at Jarosite Headland.

Beds represented by different groups of samples were measured and sampled in the places listed hereunder:

B.70 - B.73—Top of headland vertically above where south-west side of cliffs meets the beach.

B.74 - B.75—Immediately below B.73. The ledge formed by the weathering out of the 2 ft. bed at the top of B.75 may be easily identified and traced round the face of the headland. This ledge is formed by weathering of the contemporaneous wave-cut surface which is referred to in the description of the section at Point Addis. At Bell's Headland there are no pebbles on this surface but it is deeply honeycombed and is littered with macerated shells.

B.91 - B.101—Beginning at lowest outcrop on south-west side of headland in ascending sequence by a series of steps normal to the dip as successively higher

Section 5

(Measured in descending order.)

Sample No.	Thickness ft.	in.	Description
B.70	5	0	Yellow clayey siltstone.
B.71	8	0	Brown and yellow siltstone.
B.72	5	0	Brown and yellow siltstone; including 3 in. nodular layer at base.
B.73	8	0	Grey and yellow siltstone; abundant limestone nodules, weathered white.
B.74	10	0	Calcarenite; shelly fossils.
B.75	2	0	Shelly friable calcarenite; weathered out forming prominent feature (Diastem).
	8	0	Calcarenite; some shelly and friable. Top forms ledge to feature above.
—	10	0	Calcarenite—chiefly tough; some shelly and friable.
B.91	6	0	Calcarenite—chiefly tough; some shelly and friable.
B.92	3	3	Calcarenite; shelly and friable.
	0	10	Calcarenite; tough.
	3	4	Calcarenite; shelly and friable.
B.93 (5ft.)	9	3	Calcarenite; some tough, some friable.
B.94 (8ft.)	3	10	Calcarenite; tough. Crops out on rock platform and probably is lower bed of reefs opposite Jarosite Headland.
B.95	6	6	Calcarenite; cream, chiefly shelly and friable; some tough.
B.96	5	0	Siltstone; thin brown and grey alternating layers.
B.97	1	9	Siltstone; upper 9 in. grey, lower 1 ft. brown.
B.98	2	0	Calcarenite; tough.
B.99	1	6	Marl with white calcareous nodules.
B.100	5	6	Grey clayey siltstone; abundant shelly fossils in lower foot.
B.101	0	9	Finely laminated yellow clayey siltstone.
	2	0	Calcilutite; forms prominent outcrop across beach.
	0	6	Marly siltstone.
—	18	0	Estimated—no outcrop.
B.107 (B.102)	0	3/6	Quartzose calcilutite.
	6	0	Grey siltstone; abundant gastropods; much gypsum. (B.102—upper 2 ft.)
B.104	–	–	B.108 plus lower 4 ft. of B.107.
B.108	2	0	Mottled brown and yellow siltstone; cross-bedded.
B.103	1/2	0	Calcilutite; forms prominent outcrop across beach.
B.109	1	0	Grey clayey siltstone; abundant gastropods; much gypsum.
B.110	6	0	2 ft. 6 in. mottled brown and yellow sandstone. 6 in. to 2 ft. calcilutite; lenticular. 2 ft. 6 in. mottled brown and yellow sandstone.
B.111	6	0	Mottled brown and yellow sandstone.
B.112	7	0	Brown and white sandstone.
B.113 (top 6 ft.)	45	0	Pale red-purple, mottled white, greywacke with worm burrow lithology and *Cyclammina*.
—	0	6	Layer of well-rounded quartz pebbles up to ½ in. diameter.
—	–	–	Erosion surface.
B.106 (top 15 ft.)	37+	0	Brownish black siltstone with worm burrow lithology; abundant "algal" remains and *Cyclammina*.

beds are accessible from north-west to south-east; thence along and up the seaward face of the headland.

Below B.101—Beds at mouth of gully on south-west side of headland traced upwards and south-easterly to top of cliff; continuous section measured and sampled therefrom to beach level.

The section may be summarized thus:

ft.	in.	Description
26+	0	Siltstone and clay containing calcareous nodules. B.70 - B.73.
63	0	Calcarenite—chiefly tough; some shelly and friable. B.74, B.75, B.91 B.95.
49	0	Siltstone and clayey marl, containing abundant small gastropods and some non-fossiliferous calcilutite. B.96 - B.109 including zone of no outcrop.
19	0	Loosely cemented brown and white mottled siltstone and sandstone. B.110-B.112.
45	0	Pale red-purple mottled white, greywacke with *Cyclammina*. B.113.
–	–	Disconformity marked by erosion surface and layer of quartz pebbles.
37+	0	Brownish black siltstone with *Cyclammina*. B.106.

The distribution of foraminifera in the samples from Section 5 are shown in Table V. The samples are arranged in ascending sequence.

At Bell's Headland and Addiscot Beach the general sequence—calcareous rocks overlying *Cyclammina*-bearing sediments—is similar to that exposed at Point Addis and Jarosite Headland. At Point Addis the beds between the two main formations are poorly exposed and at Jarosite Headland they have been eroded away. At Bell's Headland, however, an almost unbroken sequence is exposed from the *Cyclammina* siltstone to the limestone. *It is, in fact, the only section known in the district showing this part of the sequence.* It is interesting to note that at this locality all the beds exposed appear to be marine; whereas at Anglesea there are freshwater deposits above the *Cyclammina* siltstone.

Rocky Point

Bell's Beach lies between Bell's Headland and Rocky Point. There is a small outcrop (70 ft. long and 20 ft. high) of limestone at the back of the south-west end of the beach, but from that outcrop to Rocky Point—a distance of about 500 ft. —there are no exposures.

The section, described hereunder in descending sequence, is exposed at Rocky Point (see Plate V, Fig. 2):

SECTION 6

Sample No.	Thickness		Description
	ft.	in.	
RP.9	5	0	Yellowish brown sand.
RP.8	2	0	Yellow siltstone with discontinuous 9 in. limestone bed at top.
—	5	0	No outcrop; covered by talus and soil.
RP.7	5	0	Yellow siltstone with small calcareous concretions.
RP.6	5	0	
RP.5	5	0	
—	12	0	No outcrop; covered by talus and soil.
RP.4	3	0	Marl; bottom half tough and shelly; upper half friable and non-shelly.
RP.3	5	10	2 ft. 1 in. Glauconitic foraminiferal calcarenite; tough. 1 ft. 3 in. Glauconitic foraminiferal calcarenite; friable. 2 ft. 6 in. Glauconitic foraminiferal calcarenite; tough. (The projecting bed which gives the headland its characteristic appearance.)
RP.2	3	6	Calcarenite; friable; shelly in part.
RP.1	0	7	Calcarenite; tough.
	9	2	Calcarenite; shelly, friable.
	2	0	Calcarenite; tough. Bed forming rock platform.
	1	0	Calcarenite; tough. Lowest exposure at low water.

Although the exposures at Rocky Point and Bell's Headland are only ¼-mile apart precise correlation between them requires care. The small isolated exposure at the back of the south-west end of Bell's Beach has an apparent dip 45° at 2°. The section includes a prominent bed about 18 in. thick. Sighting up the dip along this bed towards Bell's Headland suggests that it is the same as a bed exposed on the Headland in a stratigraphical position about 4 ft. below the top of B.74; sighting down the dip suggests that it is the same as the prominent ledge-forming bed in RP.3.

The distribution of foraminifera in samples from Section 6 is shown in Table VI. The samples are arranged in ascending sequence.

From Rocky Point to Torquay there is an unbroken line of cliffs. The section exposed on these cliffs is described in reverse geographical order to that used so far in this paper, for two reasons:

(i) The horizon markers used for correlation die out from east to west and and it is more convenient to describe them in that order than in the reverse one.

(ii) The exposures at Bird Rock and Fisherman's Steps are virtually the type section for the "Janjukian" so that it seems preferable to describe the section in this order—

(a) Bird Rock, thence westerly through Fisherman's Steps to Rocky Point;
(b) Bird Rock to Torquay.

Bird Rock and adjacent Bluff

There are many references in the literature to the section at Bird Rock and the adjacent bluff, the best known of the "Janjukian" sections in the Torquay-Anglesea area, but all published descriptions of it except Daintree's (1863) are in general terms. Daintree's description (see p. 79) is accurate but not sufficiently detailed for the present purpose. Section 7, described below, was measured in descending order at the point nearest to Bird Rock and the adjacent cliffs on the eastern side thereof.

The different units in this section may be recognized by reference to the following notes and to Plate VI, Fig. 1.

Broadly, as pointed out by many previous workers, the section consists of two parts—the upper friable, fine-grained and relatively less fossiliferous beds, and the lower, coarser-grained and richly fossiliferous beds. The top of BR.5 (Marker "F")—not, as has been stated (Hall and Pritchard, 1896) the hard bed (Marker "E") that forms the top of the Bird Rock stack—is the surface which naturally divides the sequence into two parts (see Plate VI, Fig. 1). The top of this bed (BR.5) is a well-marked dip surface on the eastern side of the Bird Rock Bluff where the beach ends against the rocks that form the point. Resting on it will be seen the slumped outcrops of BR.4. With this as a reference point there will be no difficulty in recognizing the higher units.

The section comprised by samples BR.5 and those below BR.5 form the lower part (an almost vertical cliff face) of the Bird Rock Point and the beds from "E" down to the base of BR.17 form Bird Rock itself. The 6 in. relatively tough bed at the top of BR.18 goes under Bird Rock on its eastern side. Bed "D" (the *Glycymeris* bed) crops out on the rock platform 50 ft. west of Bird Rock. If any difficulty is experienced in identifying it here it can be recognized very easily on

SECTION 7

Sample No.	Marker Bed*	Thickness ft.	in.	Description
—	—	5	0	Clay and soil.
BR.13	—	15	0	Mottled yellow and grey laminated siltstone.
BR.12	—	0	2	(a) (a) Nodular limestone (calcilutite)
		3	1	(b) Nodules white on exposed
		0	7	(a) surface.
		3	6	(b) (b) Marly siltstone
BR.11	—	1	1	Average of 10 in. - 1 ft. 4 in.; (a) similar to BR.12
		1	7	(b)
		0	5	(a)
		0	10	(b)
		0	3	(a)
		0	5	(b)
		0	7	(a)
		2	0	(b)
BR.10	—	0	9	Limestone similar to higher beds.
		2	0	Greenish grey marly limestone.
BR.9	—	5	3	Yellow and grey siltstone.
—	—	8	9	Yellow and grey clayey siltstone; calcareous concretions (calcilutite) at L, M and N. Beds not sampled owing to difficulty in obtaining clean outcrop. (See BR.19 to BR.25 in Section 8.)
—	N	–	–	
—	—	15	0	
—	M	–	–	
—	—	12	0	
—	L	–	–	
BR.8	—	5	2	Grey clayey siltstone.
BR.7		0	8	Grey quartzose marl; two pale yellow concretionary limestone (calcilutite) beds at top "K" and calcareous concretions "J"; gastropods common.
	K	0	8-12	
		0	8	
		2	6	
	J	0	9	
		9	0	
BR.6	H	2	0	Calcilutite; tough. Forms prominent outcrop marked by weathering out of beds below.
BR.1	—	6	2	Grey to yellow clayey siltstone.
BR.2	—	8	0	
BR.3	—	3	3	Grey clayey siltstone; abundant gastropods. Mud balls commonly about ½ in. diameter.
BR.4	G	13	0	Grey silty argillaceous calcarenite with a few calcareous concretions 3 ft. long at 1 ft. from top. Poorly exposed due to slumping. (BR.4 = bottom 4 ft.)
BR.5	F	5	0	Grey friable calcarenite; abundant glauconite and shelly fossils particularly at top; lenticular, tough band "F" at top.
BR.14	E	1	0	Grey friable calcarenite.
		1	0	Top of Bird Rock stack.
		4	0	Grey friable calcarenite.
		1	0	Brown calcarenite; harder than bed below and bed above.
BR.17		3	6	Grey friable calcarenite.
		6	0	Grey friable calcarenite; top marked by ledge on side of Bird Rock.
BR.18		0	6	Grey friable calcarenite; relatively tough 6 in. and 9 in. beds and parting between beds 3 ft. 2 in. and 1 ft. 8 in. thick.
		3	2	
		1	8	
		0	9	
		2	2	
	D	0	9	*Glycymeris* shell bed—ferruginous calcarenite.

*The marker beds are designated by letters. They scarcely have the status of members and probably none of them will ever be recognized with certainty anywhere except in the cliff sections described herein.

the point 600 ft. west of Bird Rock where it will be seen in the face of the cliff, 16 ft. above the rock platform.

The distribution of foraminifera in samples from Section 7 is shown in Table VII. The samples are arranged in ascending sequence.

To ensure adequate sampling of the beds between BR.8 and BR.9 a section (No. 8) was measured in descending sequence at the point of the bluff directly above Bird Rock.

SECTION 8

Sample No.	Marker Bed	Thickness ft.	in.	Description
BR.25	—	6	0	Yellow siltstone.
BR.24	—	6	0	
—	N	2	0	
BR.23	—	2	0	Locally prominent concretionary calcilutite.
BR.22	—	4	0	Grey clayey siltstone, decreasingly clayey upwards.
BR.21	—	5	0	
—	M	0	4	Lenticular concretionary calcilutite.
BR.20	—	5	0	Yellow marly siltstone.
BR.19	—	5	6	
—	L		6-12	Calcareous concretions (silty calcareous claystone) 3 to 6 ft. apart.
—	—	5	5	As in Section 7.
—	K	1	7	
—	—	2	6	
—	J	1	1	
—	—	9	0	
—	H	2	0	

It should be noted that the thickness of the beds between the top of "M" and the bottom of "H" is the same in this section as in No. 7. The significance of this will be discussed later (see p. 101).

The distribution of foraminifera in samples from Section 8 is shown in Table VIII. The samples are arranged in ascending sequence.

Between Bird Rock and Fisherman's Steps

The cliffs between Bird Rock and Fisherman's Steps are illustrated in Plate VI, Fig. 2.

There is an anticline between Bird Rock and Fisherman's Steps and, because of this 27 ft. of strata below the lowest beds at Bird Rock are exposed on the axis of the anticline about midway between the two localities. The *Glycymeris* bed ("D" at base of Section 7) crops out at sea level 50 ft. west of Bird Rock and at sea level 80 ft. east of Fisherman's Steps. This bed is easily traced between the localities mentioned and hence forms a convenient marker. Details of the 27 ft. of strata exposed below marker "D" at the axis of the anticline are given in Section 9.

The distribution of foraminifera in samples from Section 9 is shown in Table IX. The samples are arranged in ascending sequence.

The exact spot at which the 70 ft. bore referred to by Chapman (1922a) was put down cannot be identified, but its position is sufficiently well described to indicate that it was commenced in beds immediately below FB.1. Chapman's log of the bore is given in Section 10.

SECTION 9

Sample No.	Thickness ft.	in.	Description
FS.11	–	–	Marker "D".
FB.5	7	9	Average of 7 ft. 0 in. - 8 ft. 7 in. Grey calcarenite; very shelly. In places base is marked by tough band (calcilutite).
FB.4	4	7	Grey calcarenite; very shelly.
FB.3	4	7	Brown calcarenite; few shells.
—	1	0	Calcareous concretions in marly matrix.
FB.2	4	3	Brown and grey carbonaceous shelly calcareous siltstone; green clayey glauconitic pipes common.
FB.1/FB.A	5	3	

SECTION 10

	ft.	in.
Blue marl	23	3
Sandstone [probably calcarenite, H.G.R.]	0	7
Dark green sandy marl	3	2
Greensand	4	0
Dark green sandy marl	5	0
Blue, grey and brown marl	14	0
Brown sandy marl	20	0
	70	0

The fossils identified in the borings are listed in the paper from which the foregoing information is quoted. Chapman's comment on this bore is quoted on p. 82. Sections 7, 9 and 10 together represent a continuous sequence 258 ft. thick.

Fisherman's Steps

This locality is well known; at the time these investigations were made it was marked by wooden steps leading from large talus blocks (which rest on the rock platform) to the mouth of a shallow hanging valley. (See Plate V, Fig. 3.)

Section 11 is that exposed at Fisherman's Steps.

The following notes will facilitate recognition of the individual units in the sequence. The beds from FS.8 downwards form a nearly vertical cliff and were sampled on the north-west side of the wooden steps. The top of the bearer of the steps rests on bed "F", and the *Glycymeris* bed—"D"—crops out on the rock platform 80 ft. east of the steps. The unique lithology (at least 50% shells) and bright red colour of this bed will enable it to be identified very easily.

The higher and generally more friable beds form a steep slope receding landwards above FS.8. The slumped outcrop of FS.7 (bed "G"), rounded outcrop of FS.6 and the markers "H", "J" and "K", provide means of identifying all units in this part of the section.

As the description above indicates there is no difficulty in tracing at least seven individual beds from Bird Rock to Fisherman's Steps, so that correlation between the two is well controlled. (See also Plate VI, Fig. 2.)

The distribution of foraminifera in samples from Section 11 is shown in Table X. The samples are arranged in ascending sequence.

Between Fisherman's Steps and Dead Man's Gully

At a point about half-way between Fisherman's Steps and Dead Man's Gully a section 80 ft. thick is exposed in which certain lithological units occur which can

SECTION 11

Sample No.	Marker Bed	Thickness ft.	in.	Description
		4	0	Soil and clay.
FS.1	K	0	8	Concretionary non-fossiliferous calcilutite; pale yellow on exposed surface.
		3	4	Yellowish grey silty marl.
FS.2	J	0	8-12	Calcilutite; lenticular.
		5	0	Greenish grey marl.
FS.3		4	0	Greenish grey marl.
FS.4	H	1	3	Calcilutite; honeycomb weathering; prominent because of weathering away of beds immediately below.
		5	7	Greenish grey siltstone.
FS.5		6	10	Greenish grey siltstone.
FS.6		3	2	Greenish grey clayey siltstone; rounded outcrop.
FS.7	G	15	0	Grey silty marl; slumped and obscured by talus. FS.7 = bottom 5 ft.
FS.8	F	2	0	Tough — Shelly calcilutite (tough) to calcarenite (friable), small echinoids particularly abundant.
		1	0	Friable
		1	0	Tough
		5	0	Friable
FS.9	E	1	3	Tough — Shelly calcilutite (tough) to calcarenite (friable).
		3	0	Friable
		1	0	Tough
		3	0	Friable
		0	8	Tough
		3	3	Friable
		1	4	Tough
		0	10	Friable
FS.10		2	0	Calcarenite.
		3	0	Shelly fine calcarenite.
		1	10	*Glycymeris* shells in ferruginous calcarenite matrix.
		5	0	Fine calcarenite; tougher and less shelly than bed above.
		2	6	Friable grey fine calcarenite; shelly.
FS.11	D	1	0	*Glycymeris* shells in cemented ferruginous fine calcarenite. Shells make up at least 50% of rock.
Sea level, low tide.				

be traced continuously from Fisherman's Steps. The locality is easily identified as it is the first small indentation (forming a small cove at high water) in the cliff south-west from Fisherman's Steps.

Section 12 was measured at this locality.

Six of the markers that can be traced from Bird Rock to Fisherman's Steps can be identified easily from Fisherman's Steps to the section above described. The prominent bed "X" between "D" and "E" provides additional means of correlation and many beds could be traced from one section to the other if additional correlation ties were desired. Locally the grey calcilutite in FD.1 is especially prominent.

The following details will enable the different units of the section to be readily identified in the field. The samples FD.6 to FD.4 and below FD.1 were obtained on the north-eastern side of the south-west point of the cove. Samples FD.3 to FD.1 were obtained on the south-western side of the south-west point of the cove.

SECTION 12

Sample No.	Marker Bed	Thickness ft.	in.	Description
FD.5, 6, 16	—	25	0	Light grey clayey siltstone, mottled yellow. FD.16 full thickness; FD.5 bottom 1 ft. 4 in;. FD.6 14 ft. 8 in. above FD.5.
	K	0	9	Pale yellow calcilutite.
FD.4, 15	—	3	0	Grey silty marl; mottled light grey.
	J	1	4	Dark grey calcilutite.
FD.3, 14	—	9	6	Yellowish grey marl; gypsum abundant.
	H	1	4	Dark grey calcilutite.
FD.13, 2	—	4	6	Mottled grey clayey marl. FD.13 full thickness; FD.2 top 2 ft.
		–	–	Calcareous concretions.
FD.12	—	3	8	Mottled grey clayey marl; gypsum abundant.
FD.11	—	2	6	Friable grey clayey marl.
FD.1 { FD.10, FD.8	—	6	2	Grey clayey siltstone with dark grey patches; abundant gastropods. FD.10 full thickness; FD.8 bottom 2 ft.; FD.8 upper 4 ft. 2 in.
		1	3	Grey calcilutite, locally prominent.
FD.7,	G	10	3	Grey silty marl; upper 3 ft. mottled lighter; pencil-like concretions of pyrite.
FD.9		6	0	Calcarenite and fine calcarenite alternating. (Top = horizon of marker "F".)
No change in lithology as compared with Fisherman's Steps, hence no samples.	E	2	0	Calcilutite.
		11	8	Calcarenite; *Glycymeris* sporadically distributed; twinned gypsum crystals common near top.
	X	2	0	Fine calcilutite.
		7	2	Calcarenite.
		0	3	Shelly band, abundant broken *Glycymeris* shells.
		3	4	Calcarenite.
	Y	0	4	Shelly band, *Glycymeris* abundant.
		2	8	Calcarenite.
	D	0	3	*Glycymeris* shell bed.
		3	0	Calcarenite with pipes and lenses of green glauconitic clay.
Beach level.				

Samples FD.7 and 8 were taken on the south-west side of the north-east point of the cove.

The distribution of foraminifera in samples from Section 12 is shown in Table XI. The samples are arranged in ascending sequence.

Dead Man's Gully

Section 13 is that exposed at Dead Man's Gully.

In comparing this section with those to the east thereof, it will be noted that only three of the markers ("J" and "H" and the horizon of "F") traced continuously from Bird Rock may be identified. Bed "K" is present on the eastern side of the cove (FD.), in which Section 12 was measured, but comes to an end about half-way round the cliff above the cove and cannot be identified farther west. Bed "E" can be traced with certainty only about three-quarters of the distance from FD. to Dead Man's Gully. Although bed "D" itself cannot be recognized as a distinct marker its stratigraphical position is not in doubt as a similar *Glycymeris* bed "Y" 2 ft. 8 in. above "D" at locality FD. can be traced from Dead Man's Gully.

Section 13

Sample No.	Marker Bed	Thickness		Description
		ft.	in.	
		16	0	Grey silty marl.
	J	0	10	Yellowish brown calcilutite.
		8	10	Yellow sandy marl with nodular calcareous concretions, white on surface.
	H	1	4	Yellowish brown concretionary calcilutite.
DM.4		3	3	Clayey marl.
		0	4-6	Concretionary cream calcilutite—locally prominent, but limited lateral extent.
		3	2	Grey siltstone, mottled yellow.
DM.5		13	0	Grey sandy marl, mottled yellow with concretionary calcilutite 2 ft. from top.
DM.1		9	10	Grey clayey marl.
DM.2		0	6	Shelly band. (Top = horizon of marker "F".)
		2	2	Calcarenite.
DM.3		7	7	Grey calcarenite. Small echinoids abundant.
		3	0	Calcarenite, shelly.
		2	4	Calcarenite, shelly; tougher than bed above.
		3	6	Calcarenite, alternating tough and friable beds.
		0	6	Clayey marl.
	X	1	1	Calcilutite; tough (locally prominent; traceable from Fisherman's Steps).
		3	5	Shelly calcarenite—layer of shells at base.
		1	2	Calcilutite; tough (forms prominent ledge at mouth of gully).
		2	2	Calcarenite.
		1	5	Calcilutite; tough.
		1	9	Shelly calcarenite.
	Y	0	2	*Glycymeris* shell bed.
		6	6	Grey shelly calcarenite with pipes and lenses of glauconite and concretionary lenses of calcilutite up to 20 ft. in length.

The bed "X" which is prominent at locality FD. is easily identified at Dead Man's Gully.

The lower part of the section at Dead Man's Gully is made up of a number of individual units including dense unfossiliferous calcilutite as compared with the generally poorly bedded highly fossiliferous calcarenite in the lower part of the section east of Dead Man's Gully.

The distribution of foraminifera in the samples from Section 13 are shown in Table XII. The samples are arranged in ascending sequence.

Between Dead Man's Gully and Rocky Point

The changes in lithology and the dying out from east to west of the marker beds continue as far west from Dead Man's Gully as details can be observed.

Section 14 was measured at a point 1,200 ft. west of Dead Man's Gully.

Bed "J" is the only marker in the upper part of the section which persists to this point. The dividing surface—top of 1 ft. 1 in. bed of calcareous sandstone—between the upper and lower parts of the section can be identified with reasonable certainty but there are no other correlation controls.

It is not possible to trace any individual bed, in the upper part of the section, between this locality and Rocky Point because the cliff decreases in height and its upper part is covered with scrub.

SECTION 14

Marker Bed	Thickness ft.	in.	Description
	–	–	Yellow silty marl.
J	1	5	Yellowish brown calcilutite.
	41	0	Yellow sandy marl with calcareous nodules (white on surface) in upper portion.
	1	1	Hard grey calcareous sandstone. (Top = approx. horizon of marker "F".)
	1	9	Sandy calcarenite; friable.
	1	0	Grey sandy calcarenite; tough.
	1	8	Sandy calcarenite.
	1	9	Grey calcilutite; tough.
	3	7	Yellowish grey silty calcarenite.
	0	6	Calcilutite; tough.
	2	5	Yellowish grey silty calcarenite.
	15	0	Fine silty calcarenite.

The lower, harder, part of the section can be traced between the two localities, but individual beds are not continuous and there are a few short breaks (one of 200 ft.) in the exposures so that it is impossible to make a close correlation. However, the beds are almost flat and the dividing surface between the upper and lower parts of Section 14 can certainly be identified at Rocky Point wtihin a few feet.

Between Bird Rock and Mouth of Jan Juc Creek

From a point 300 ft. east of Bird Rock the Tertiary beds are covered with sand and soil for a distance of 100 ft. Immediately east of the soil covered area, Section 15 is exposed in the cliffs.

SECTION 15

	Thickness ft.	in.	Description
	27	0	Calcarenite (tough and friable beds of about same grain size alternating); greenish yellow on weathered surface, pale cream when freshly broken.
*	0	4	Off-white sandy calcarenite with echinoids, 2½ in. in diameter.
	24	0	Similar to 27 ft. above.
	30	0	No outcrops; grass covered slope.
	0	9	Calcilutite; serpulae abundant.
	1	6	Grey clayey marl; shelly.
	0	9	Calcilutite; lenticular.
	1	2	Grey clayey marl; shelly.
	0	7	Calcilutite; concretionary.
	1	9	Grey clayey marl with abundant gastropods.
	0	9	Calcilutite; concretionary, shelly.
	5	0	Grey clayey marl.

* Marker "O".

This section was not sampled because a more complete one (Section 17) is available near Jan Juc Creek. It is introduced here for the purpose of discussing correlation with the Bird Rock section.

As mentioned on page 79, Daintree (1863) regarded the limestone (calcilutite) at the top of Section 15 as being above the highest beds exposed at Bird

Rock. Tate and Dennant (1893, 1895) and later Hall and Pritchard (1896) considered Daintree to be in error and they correlated the limestone with the upper part of the Bird Rock section. Later writers (Singleton, 1941, p. 39) have accepted this view. Examination of the cliff face certainly suggests that the limestone is equivalent to the upper part of the Bird Rock section, but measurement shows that the eye is deceived to some extent. There is a slight change of strike and a marked change in amounut of dip between the two exposures, and the face of the cliff is concave seawards; these factors combine to suggest to the eye that the upper beds thin to the west. As pointed out on page 95, comparison of Sections 7 and 8 shows that this thinning does not occur.

An attempt was made to establish the relationship between the sections exposed on each side of the soil covered area. The last identifiable outcrop east of Bird Rock when the locality was first visited during this investigation was bed "M". The nearest reliable dip (on bed "H") to this outcrop on the western side of the soil covered area was 16° on a bearing of 350°. The beds on the eastern side of the soil covered area had a dip 3° on a bearing of 355°. The horizontal distance between the outcrops on either side of the gap normal to the strike was 90 ft. From these measurements it was estimated that the stratigraphical interval represented by the gap is 15 ft. Thus, if there is no faulting the lowest exposure east of the gap is 15 ft. above bed "M". There is support for this conclusion in the general resemblance between the limestones with closely spaced concretions in the lower part of Section 15 and the beds represented by BR.10 - BR.12.

The outcrops mentioned in the foregoing discussion will probably be those mostly commonly exposed but better evidence was obtained early in 1949. At that time storms occurred during a period of extreme high and low tides. As a result slumping took place on the cliff face. This obscured some of the details above referred to, but the hard beds in a total thickness of 46 ft. above marker "H" were exposed and could be examined at low water. (They have been covered again since then.) Moreover, the interval between the highest bed thus exposed and the base of BJ.1 (see Section 17) could be measured and was found to be 23 ft. The direction and amount of dip of the exposed beds was accurately measurable and it was possible to confirm that there is no faulting and that there is a slight change in dip direction from the lowest bed "H"—350°—to the highest bed—355°—accompanied by a gradual change in amount of dip from 16° to 3° respectively.

The section exposed revealed the details given in Section 16.

SECTION 16

Marker Bed	Thickness ft.	in	Description
N	0	9	Discontinuous nodular calcareous concretions.
	9	0	*
	1	0	Two concretionary limestone (calcilutite) beds separated by more friable strata.
	4	6	*
M	1	0	Limestone (calcilutite)
	14	0	*
K	1	0	Limestone (calcilutite)
	16	0	*
H	–	–	Top of bed "H".

* Not exposed.

These measurements leave little room for doubt that the highest bed exposed by the storms is "N" and, as the position of "N" in Section 17 is known, the relationship between the Bird Rock Section and the limestones east of it can be established. It will be seen by reference to Fig. 7 that these measurements indicate that the limestones of Section 17 are stratigraphically equivalent to part only of the marl and siltstone of the Bird Rock Bluff (Section 7). Thus, although Daintree was wrong in detail he was right in stating that three distinct lithological units are exposed.

The off-white sandy calcarenite (Marker "O") near the top of Section 15 was found very useful in maintaining correlation easterly from Bird Rock. As shown in Section 15 it is 24 ft. above the base of the calcarenite that forms the cliff east of Bird Rock; at the mouth of Jan Juc Creek it is 26 ft. 9 in. above the base of those beds.

Section 17 is a composite one, of the beds exposed between Bird Rock and Jan Juc Creek.

Details of the section may be recognized by reference to the following notes:

BJ.1 - BJ.5 form the bare cliff exposures and the details given were measured at and west from the point where the limestone ledges pass under the sand at the mouth of Jan Juc Creek. (Sometimes exposed and at others covered.)

BJ.6 and BJ.8 were measured at a point about 200 ft. east of Section 15.

BJ.7 was measured 80 ft. east of BJ.6.

The lower part of the section (below BJ.8) is the same as the lower part of Section 15.

The relationship between this Section and that at Bird Rock is discussed above.

The distribution of foraminifera in samples from Section 17 is shown in Table XIII. The samples are arranged in ascending sequence.

Jan Juc Creek to Spring Creek

The first outcrops east of the mouth of Jan Juc Creek so closely resemble those to the west of it that the section was not measured in detail or sampled. These outcrops form a cliff 460 ft. long and 30 ft. high. The off-white sandy calcarenite marker "O" is clearly defined 5 ft. from the top, and at this point is 24 ft. above the top of a ledge-forming calcarenite bed 10 in. thick, which, therefore, may reasonably be correlated with the calcarenite one foot thick at the base of BJ.1 in Section 17.

Cemented cross-bedded calcareous sands of late Tertiary to Sub-Recent age form the cliff front for 1,000 ft. east of the outcrops referred to in the preceding paragraph. At this point—at dead low water—the ledge-forming calcarenites, which form the lower part of the section on both sides of Jan Juc Creek, are exposed. The higher beds are a slightly different facies from that represented by the BJ. samples. Bedding planes are poorly defined and the rock is fairly generally a friable, yellow, silty calcarenite with some discontinuous relatively well-cemented thin beds of calcilutite. (See Plate VI, Fig. 3.)

Section 18 was measured in descending sequence at and near the old wooden steps on the southern side of Jan Juc Point.

The distribution of foraminifera in samples from Section 18 is shown in Table XIV. The samples are arranged in ascending sequence.

SECTION 17

Sample No.	Marker Bed	Thickness ft.	in.	Description*
—	—	9	6	Calcarenite (type a). Note: all calcarenites in this section are greenish yellow on weathered surface and pale cream on broken surface.
BJ.5	—	13	0	
BJ.4		4	6	Calcarenite (type b); echinoids abundant at top.
	O	1	1	Off-white sandy calcarenite.
		1	1	Calcarenite (type b); echinoids common.
BJ.3		2	1	Calcarenite (type b).
		0	2	Calcarenite (type a).
		2	4	Calcarenite (type b).
		1	2	Calcarenite (type a).
		3	8	Calcarenite (type b); nodular calcilutite concretions common.
		1	0	Calcarenite (type a).
BJ.2		5	2	Calcarenite (type b).
BJ.1		1	0	Calcarenite (type a).
		1	2	Calcarenite (type b).
		0	10	Calcarenite (type a).
		1	9	Calcarenite (type b).
		0	10	Calcarenite (type a).
		3	6	Calcarenite (type b).
		1	0	Calcarenite (type a).
BJ.6		1	10	Yellow clayey marl.
		0	10	Calcarenite.
		2	4	Yellow sandy marl with calcareous nodules.
		0	9	Calcarenite.
		2	10	Yellow sandy marl with calcareous nodules.
		0	3	Calcarenite.
BJ.7		8	0	Grey clayey marl.
		0	5	Calcilutite.
		0	9	Grey clayey marl.
BJ.8		0	5	Calcilutite.
		2	0	Grey clayey marl.
Not Sampled		1	6	Grey clayey marl.
	N	0	9	Calcilutite; lenticular.
		1	2	Grey clayey marl; shelly.
		0	7	Calcilutite; concretionary.
		1	9	Grey clayey marl with abundant gastropods.
		0	9	Calcilutite, concretionary, shelly.
		5	0	Grey clayey marl.
		–	–	Beach.
	Thickness	87	6	

* Calcarenite (type a) well cemented, rough.
*Calcarenite (type b) friable, silty, argillaceous.

Spring Creek to Yellow Bluff

Spring Creek marks the southern end of the Torquay surfing beach. There are outcrops of calcarenite and clayey marls at the northern end of this beach—i.e. on the southern side of Point Danger—on the northern side of Point Danger and on the point (Yellow Bluff) at the northern end of Zeally Bay which clearly are generally to be correlated with the section at Jan Juc Point. However, as the beds at Jan Juc Point are almost horizontal and those on the southern side of

Section 18

Sample No.	Thickness ft.	Description
T.7	5 - 15	Yellow and grey clay. Erosion surface.
T.5	5 - 11	Friable yellow sandy calcarenite, some relatively hard lenticular shelly beds.
T.4	8	
T.3	8	
T.2	6	
T.1	7	Yellow sandy calcarenite, bedded and shelly at base.
—	6	Beach—no outcrop.
T.8	8	Shelly calcarenite; some relatively hard thin beds forming ledges (exposed at dead low water).

Point Danger dip at angles up to 10°, precise correlation between them would only be possible on the basis of some reliable lithological criterion, or on palaeontological evidence. Neither method has given sufficiently precise results for our present purpose. The calcarenite on the northern side of Point Danger contains large numbers of well-preserved tests of *Operculina*.

Anglesea to Airey's Inlet

From Point Roadknight, which consists of Sub-Recent cemented cross-bedded sands, to Urquhart's Bluff—a distance of 3 miles—there are few outcrops of the Tertiary beds. At low tide reefs are exposed between these localities which are composed of the same rock as Point Roadknight. They are mentioned solely because for considerable distances they have a strike and dip parallel to the regional strike and dip, are inclined at angles up to 10°, and might therefore be mistaken for Tertiary strata.

At Urquhart's Bluff, the outcrop consists of volcanic agglomerate, and it is important to determine the relationship of these rocks to the Anglesea section.

The slope of the surface between the Anglesa boat harbour and Urquhart's Bluff is fairly certainly a dip slope. The outcrops in road cuttings and gullies between these two points are poor but the rocks exposed closely resemble the lighter-coloured marine beds in the upper part of the section at Anglesea. In the road cutting above Urquhart's Bluff yellowish-grey to purple sandy clays and one prominent yellowish-brown sandstone bed 18 in. thick are exposed. These beds overlie the agglomerate at Urquhart's Bluff. It seems reasonable to conclude that the yellowish-grey to purple clays represent the uppermost clays (W.102) at the Anglesea boat harbour, that the yellow sandstone represents W.101, and that the volcanic agglomerate at Urquhart's Bluff may be correlated with the clastic volcanic rocks at and near Soapy Rocks.

Volcanic rocks, dominantly basaltic tuff, breccia or agglomerate crop out continuously from Urquhart's Bluff to Split Point and may be examined both on the rock platform and in cliff sections up to 50 ft. high. These beds show marked cross-bedding, a detailed examination of which may throw some light on the position of the crater from which the volcanic ejectamenta were derived; as remarked by Hall (1910) it could not have been far distant—the extent of the volcanic rocks is limited, and boulders up to four feet in diameter are present in large numbers. The thickness of the volcanic rocks cannot be determined accurately as their base is not exposed but it is not less than 50 ft. This thickness is exposed below the limestone (described below) in the cliff below the camping ground near "Sunnymeade" house. This locality, shown on the military map (Anglesea sheet) is about 1¼ miles north of Split Point.

At Split Point and Table Rock remarkable sections are exposed showing limestone (calcarenite) resting upon volcanic agglomerate. Krause (1874, p. 100) refers to these. The upper surface of the volcanic rocks in most places is marked by a bed of boulders—one boulder thick—derived from the agglomerate. In places the boulder bed is absent, and at one locality at least—¼-mile north of Eagle Rock—12 ft. of well-bedded coarse quartz sandstone occurs between the boulder bed and the overlying limestone. There is an excellent exposure at the foot of Table Rock showing shelly marl and limestone resting on an irregular surface of agglomerate. In places, hollows in the agglomerate several feet deep are filled with masses of shells. Hall (1910) referring to these exposures wrote: "the surface of the underlying basalt is cut by channels and is very bouldery, so that the limestone forms deep pockets . . . some of these pockets go down to 20 ft. below the main mass".

Section 19 was measured and sampled at Split Point, opposite Table Rock. A track leads down the cliffs to this locality at a point about 660 ft. south-west of the lighthouse.

SECTION 19

Sample No.	Thickness ft.	Description
A.11	13	Calcarenite; types (a) and (b)* alternating.
A.10	4	Calcarenite; type (a); flat echinoids.
	4	Calcarenite (quartzose); type (b); flat echinoids.
A.9	6	Quartzose calcarenite; type (b); small echinoids abundant.
—	10	
A.8	2	
A.7	8	
A.6	6	Calcarenite; types (a) and (b) alternating.
A.5	4	Quartzose calcarenite; type (a).
A.4	6	Shelly calcarenite; type (a).
A.3	6	Shelly calcarenite; type (a).
A.2	6	Calcarenite; type (a).
—	–	Volcanic agglomerate.
Thickness	75	

*For definition see p. 103.

The distribution of foraminifera in the samples from Section 19 is shown in Table XV. The samples are arranged in ascending sequence.

Airey's Inlet to Eastern View

Between the mouth of Airey's River (Painkalac Creek) and Eastern View there are no cliff sections and the exposures in the creek beds and road cuttings are discontinuous. When the Great Ocean Road was first cut some good sections were probably available for examination, but most of these are now partly obscured. However, the exposures in this locality are notable because they reveal the only known natural sections in the whole of the coastal region east of Cape Otway of the lowest part of the Tertiary sequence.

Hereunder notes are given about the outcrops between Eastern View and Airey's Inlet from west to east, i.e. in ascending stratigraphical sequence.

On the beach exposed at low tide between Spout Creek and Coalmine Creek, coal measures are exposed overlying Jurassic greywacke. The underwater outcrops of the coal seams show out very clearly in air photographs (Plate IV, Fig. 1). Krausé (1874) recorded an outcrop exposed at low water opposite the mouth of Spout Creek (his plan No. 3). This is now covered with sand. Section 20 was measured between Spout Creek and Coalmine Creek.

SECTION 20

Thickness ft.	in.	Description
2	0	Lignite.
16	8	Ferruginous fine conglomerate.
2	4	Lignite (dip 120° at 35°).
4	7	Ferruginous fine conglomerate and sandstone.
1	9	Lignite.
27	6	No outcrop.
3	0	Lignite with large pieces of wood.
21	10	No outcrop.
3	5	Lignite.
58	6	No outcrop.
2	0	Lignite.
40	2	Ferruginous coarse sandstone.
66	0	No outcrop (pebbly coarse sandstone in Coalmine Creek).
–	–	Greywacke—Jurassic (dip 115° at 41°).
249	9	

When Krausé (1874) visited the locality, prospecting for coal was in progress in Stony (now Coalmine) Creek. Signs of this can still be seen 115 ft. upstream from where the Great Ocean Road bridge spans the creek; a further 50 ft. upstream Jurassic greywacke is exposed. Combining measurements of natural exposures with information obtained from shafts and a bore, Krausé compiled Section 21 (his Section No. VI).

Krausé's section gives details of the beds not exposed in the lower part of Section 20. Precise correlation between Sections 20 and 21 cannot be made but the lowest seam in Section 20 is possibly represented in Section 21 by the 1 ft. 8 in. of brown and black clay, in part bituminous (74 ft. from top).

Krausé shows a slight unconformity between Jurassic and Tertiary. The dips he gives are respectively 26° on a bearing of 130° and 22° on a bearing of 120°. The authors' observation is that both dip approximately at 32° on a bearing of 130°.

On the north side of the Great Ocean Road 30 ft. east of the bridge over Coalmine Creek purplish grey clayey siltstone is exposed in a small pit. The siltstone closely resembles some of the higher marine beds at Anglesea but it contains no fossils.

At the top of the hill immediately behind a private house on the Great Ocean Road named Bills-o-Jacks* a partial section (Section 22) was exposed by a washaway during heavy rains in October, 1949.

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*First house on west side of "Great Ocean Road" pergola.

SECTION 21 (After Krausé)

Thickness ft.	in.	Description
10	0	Ironstone and conglomerate.
40	0	Soft white and yellowish sandstone with bands and layers of harder ferruginous sandstone.
18	0	Yellow brown and red clay with ironstone nodules.
6	0	Soft yellowish-white sandstone with round pieces, sulphate of iron.
0	3	Dark brown clay.
0	8	Black bituminous sandy clay.
0	9	Dark brown clay.
22	0	Soft grey-white sandstone, the upper portion with carbonaceous fragments.
9	6	Fine white sand.
11	8	Yellow and brown siliceous sand.
9	6	Hard sandstone-grit.
5	3	Grey foliated micaceous soft sandstone with leaf impressions.
15	0	White coarse sand bed.
7	4	Yellow and grey sandy clay.
6	0	Shaley lignite.
3	0	Good strong brown coal rich in carpolithes.
5	0	Shaley lignite showing dicotyledonous structure.
2	8	Soft brown sandy shale which sustains a flame.
1	6	Woody brown coal.
9	0	Sandy clay.
10	6	Grey soft sandstone.
5	3	Loose sand.
5	3	Greyish-white clay.
15	6	Brown clay.
5	0	Sandy shale with sulphate of iron.
224	7	
		Mesozoic sandstone.

SECTION 22

Sample No.	Thickness ft.	in.	Description
	6	6	Yellowish brown friable laminated sandstone.
	0	2	Reddish brown friable sandstone (dip 130° at 25°).
EV.5	14	6	Light buff fine friable sandstone. Colour changes to light brown at base. Ferruginous concretions up to 3in. in diameter, 2 ft. above base.
	2	3	Dark brown to black lignite with laminae of fine sand, grading down into—
EV.4	2	0	Brown silty fine friable sandstone with some mica.
	4	0	Light brown fine friable sandstone with some mica.
EV.3	1	6	Light brown fine friable laminated sandstone.

No fossils were found in the samples taken.

Measurements in the field and examination of air photographs suggest that the lignite seam in this section is the one third from the top in Section 20.

The same heavy rains that exposed Section 21 gouged out the gutter on the north side of the road leading uphill from Bills-o-Jacks and exposed white fine silty sandstone and a coal seam between the bottom of the hill and the first bend in the road.

At the top of the hill behind the Eastern View Hotel a partial section (Section 23) is exposed.

SECTION 23

Sample No.	Thickness ft.	in.	Description
	1	0	Silty sandstone.
	0	6	Silty sandstone; platy ferruginous layers along bedding planes.
EV.7	8	0	Grey silty sandstone.
	1	0	Concretionary ferruginous layer.
	19	0	Grey silty sandstone.
	6	0	Grey medium quartz sandstone—mottled yellow and brown.
	0	0½	Ironstone.
	0	6	Grey silty sandstone.
	4	6	Mottled grey brown and yellow medium sandstone with ferruginous layers at base.
EV.6	30/40	0	Grey clayey sandstone; ferruginous platy layers.

This section provides some details of beds which clearly are above the observed coal seams but its stratigraphical position cannot be determined accurately. No fossils were found in the samples taken from these beds.

On the east bank of Mogg's Creek adjacent to the downstream side of the Great Ocean Road bridge, a section about 10 ft. thick of pale red-purple silty sandstone and ferruginous coarse sandstone with carbonaceous fragments was exposed in March, 1948. (This section was covered with sand when the locality was visited early in 1949, in October 1949, and in October 1950.) Similar beds may be seen, however, on the north side of the Great Ocean Road between 360 and 540 ft. east of the bridge over Mogg's Creek; they dip at 30° on a bearing of 350°. *Cyclammina* is abundant in the silty sandstone. The thickness of the beds exposed in 1948 is at least 100 ft.

In road cuttings 0·67 mile and 0·8 mile east from Mogg's Creek dips of 13° on a bearing of 110° and 4° on a bearing of 100° respectively were noted. *Cyclammina* is present in the silty sandstone exposed.

Three hundred feet west of a small creek 1 mile east of Mogg's Creek (½ mile west of Airey's River) 40 ft. of very pale red-purple siltstone with thin beds of coarse sandstone are exposed. These beds dip 3° on a bearing of 85°. Two hundred feet west of the same creek a partial section (Section 24) was measured in April, 1949.

SECTION 24

Thickness ft.	in.	Description
16	6	Medium quartz sandstone with layers of coarse quartz sandstone and grey clay up to 3 in. thick.
7	2	Red and grey clay. (Acid ashstone (Dallwitz, 1954).)
10	0	Medium quartz sandstone with layers of coarse quartz sandstone up to 3 in. thick.

The beds dip 3½° on a bearing of 80°; they are unfossiliferous.

At the western end of the Great Ocean Road bridge over Airey's River (Painkalac Creek) about 45 ft. of clays and coarse sandstone are exposed which dip

4° on a bearing of 195°. They contain no fossils. The base of this exposure is 10 ft. above sea level and the beds therefore must underlie the limestone (Section 19) at the mouth of the river.

The fragmentary information obtained in the field and described above has been supplemented by examination of air photographs, mainly with the object of seeing whether the observations made on the structure of the beds exposed between Eastern View and Airey's River are sufficiently reliable to form a basis for calculation of thickness. It has been concluded that they are. The probable thickness of the beds exposed is therefore:

4. 70+ ft.—Sandstone and clay; acid ashstone noted in one place. No fossils.
3. 1,200 ft.—Siltstone with some sandstone; *Cyclammina* abundant.
2. 1,200* ft.—Sandstone; no fossils.
1. 300 ft. (292 ft. 2 in.)—Jurassic Coal Measures.

Definition and Description of Rock Units

In the previous part of this paper the sections exposed between Torquay and Eastern View have been described. Those descriptions were given without regard to stratigraphic classification based on lithology or time. In this part of the paper the data presented are examined and the rock and time-rock (time-stratigraphic) units defined. The columnar sections (Fig. 7) provide a summary not only of the stratigraphic data, but of the correlations outlined in the previous section of the paper.

In considering the names of lithological units and the definition of time-rock units the necessity as far as practicable, to retain old names, and at the same time to conform to the principles of the Australian Stratigraphic Code (Raggatt, 1950) has been carefully observed. To satisfy these two conditions is not easy.

The broad lithological classification of the sediments is a simple exercise in the application of the principles of the Code. If the problem were merely to name and define the lithological units and discuss their age in relation to an established time scale there would be no difficulties. However, these difficulties arise through attempting to relate the name of lithological units to time-rock terms, some of which have been defined by reference to sections exposed in the area dealt with in this paper. Particular difficulties are introduced because:

(i) Two time-rock terms ("Anglesean" and "Janjukian") have been described by reference to sections in the area described. If possible, therefore, it is desirable to choose major rock unit names so that "Anglesean" and "Janjukian" can be related to the names chosen. This is in conformity with classical procedure—that followed, for example, in naming most of the Systems.

(ii) "Anglesean", "Janjukian", "Batesfordian" and "Balcombian" were all defined without relation to each other.

(iii) Although the whole of the section exposed at the type localities was nominated by their authors as "Janjukian" and "Balcombian" the faunal criteria suggested as diagnostic of the Stages as a whole are based on fossils collected predominantly from only part of the type sections. (Tate and Dennant, 1895; Singleton, 1941, pp. 27 and 39.)

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*Erroneously recorded as 1,730 ft. in Raggatt and Crespin (1952).

(iv) The relationship between "Janjukian" and "Balcombian" has been confused by bringing into the discussion palaeontological criteria from beds not demonstrably referable to either.

The difficulties thus introduced by errors in concept and procedure are increased by errors in observation:

(i) The limestone at the top of the type "Janjukian" (i.e. between Torquay and Bird Rock) has been correlated with the limestone near its base (at Rocky Point). It is only after repeated reading of the earlier papers on the background of some knowledge of the locality that it is realized that all the previous workers who expressed an opinion on this point made the error of correlating the highest limestone in Daintree's (1863) section with the limestone at Rocky Point. (Relevant references are: Tate and Dennant 1893, p. 211; Hall 1910, p. 50; Singleton 1941, p. 38.)

(ii) It has not been recognized that in the coastal sections exposed between Eastern View and Torquay, the sequence of Tertiary formations in ascending order is: (a) Coal measures, (b) non-fossiliferous sandstone, (c) *Cyclammina*-bearing siltstone and greywacke, (d) dominantly fresh water sediments and volcanic rocks, (e) highly fossiliferous limestones (calcarenites) and (f) marls and siltstones much less fossiliferous than (e).

Before naming the lithological units in the lower part of the sequence it is necessary to determine as precisely as possible the meaning given to "Anglesean" and "Janjukian".

Singleton introduced the name "Anglesean" in 1941. On p. 24 he stated: "Here proposed for the black sandstone and sandy clays of the coastal cliffs . . .", and p. 25 ". . . the interval of time represented by the deposition of the dark coloured sands with *Cyclammina*, of the cliff sections . . .". On p. 13 he implies that he regarded the beds with lignite as a facies of the *Cyclammina sands;* he wrote that underlying the type marine Janjukian "in turn are the so-called lignite beds, . . . they outcrop as dark carbonaceous sand with *Cyclammina* . . .". His statement on p. 69 makes this a little clearer. He wrote: ". . . the richly fossiliferous Janjukian beds are underlain by strata, probably referable to the Anglesean, which in some cases contain *Cyclammina* and are often lignitiferous towards the base". In his Fig. 11, p. 65, he shows a lignite bed about the middle of the Anglesean. In making some of these statements Singleton was possibly influenced by Hall's comment, ". . . between Point Castries and Airey's Inlet [i.e. at Eastern View—H.G.R.] occurs a series of beds which are clearly of Tertiary age but whose relationship to the beds farther east has been a matter of doubt. They have been described in some detail by Krausé, since close to the Jurassic they contain lignite seams . . . . It seems almost certain that these western beds represent the black beds of Anglesea and are of freshwater origin." (Hall, 1910, p. 50.) That is, Hall regarded the Coal Measures at Eastern View as a facies of the black beds with *Cyclammina* at Anglesea.

Singleton's placing of the upper limit of the "Anglesean" at the top of the "black sands" at Anglesea was more or less accidental, and due to the fact that in his early work he did not recognize either the nature of the contact between the "black sands" and the overlying beds, or the close lithological and palaeontological similarity of the overlying beds to the "black sands". Later he noted that the "Janjukian" rested conformably on the "Anglesean" (note from O. P. Singleton to E. S. Hills), so that we may reasonably assume that in his later years his interpretation of the succession was not very different from that given in this paper.

Bearing in mind the objective of trying to name a rock unit so that "Anglesean" can be related to it as a Stage name, definition and usage allow of three ways of using "Anglesea" in the name of a rock unit:

(a) strictly as originally proposed by Singleton,
(b) as the name of all the beds with *Cyclammina* at Anglesea,
(c) to include all the Tertiary beds below the base of the "Janjukian".

Reference to the discussion on pages 131-136 shows that the stratigraphic interval represented by (c) is Palaeocene to Middle Eocene, so that this cannot be adopted. Usage (b) would be better than (a) because its upper contact is with marine beds of determinable age, but otherwise it is open to the same general objections as (a), namely (i) its base rests upon unfossiliferous sediments, and (ii) it contains no fossils of age significance.

For these reasons "Anglesea" has been retained as the name of a rock unit strictly as proposed by Singleton, but it is suggested that the term "Anglesean Stage" should be abandoned and new Stages in the pre-Janjukian sequence defined when adequate evidence is available. It may be noted that Singleton (1941) himself stated that the section at Demon's Bluff was "by no means ideal as a type".

The type "Janjukian" as defined by Hall and Pritchard (1902) and by Singleton (1941) includes all the beds in the Torquay-Rocky Point cliff sections. This name is so widely used in the literature that it is desirable to retain it if possible.

Although all the beds exposed in the cliffs between Torquay and Rocky Point were named "Janjukian" the faunal criteria used for identifying the "Janjukian" are based largely on a knowledge of the shelly fossils from the lower 60 ft. of the section (see p. 80 for statement quoted from Tate and Dennant, 1895; Singleton, 1941, p. 39). The lower half is not only much more fossiliferous than the upper half, but it is easily accessible in many places, whereas the upper half is not. Palaeontological criteria have been confused also, as noted above, by the error made in correlating the limestones at Rocky Point with those at Torquay.

The shelly fauna of the type "Balcombian" occurs mainly in three feet in the middle of the section (Singleton, 1941, p. 27).

It is shown later in this paper that the microfauna of the upper part of the section nominated as "Janjukian" by Hall and Pritchard and by Singleton (Torquay Group of this paper) is characteristically "Balcombian", and therefore that "Janjukian" and "Balcombian" as originally defined overlap each other; both must, therefore, be re-defined.

It is proposed to name the lower beds in the Torquay-Rocky Point Section the Jan Juc Formation and to define Janjukian in relation thereto. Names are proposed also for the lithological units in the upper beds of the Torquay-Rocky Point Section.

The rock units defined and described are:*

Torquay Group {
- Puebla Formation
  - Zealy Limestone Member
- Jan Juc Formation
  - Point Addis Limestone Member

}
- Demon's Bluff Formation
  - Angahook Member
  - Addiscot (Greywacke) Member
  - Anglesea (Siltstone) Member
- Boonah Sandstone
- Eastern View Coal Measures

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*These have been approved by the Victorian members of the A.N.Z.A.A.S. Committee on Stratigraphic Nomenclature.

In the table above, the formations are placed in their normal stratigraphic sequence. They are described in the reverse order, i.e. commencing with the oldest.

Eastern View Coal Measures

This name is applied to the Coal Measures at the base of the Tertiary sequence exposed in the coastal sections described in this paper. The Coal Measures rest on the Jurassic and are overlain by sandstone (Boonah Sandstone) in which no fossils have been found. It is difficult to define the upper limit of the Coal Measures precisely because neither the Coal Measures nor the overlying Boonah Sandstone form good outcrops. In interpreting bore logs the upper limit has been placed at the top of the highest coal seam.

The type locality is Eastern View, the only place in the coastal strip described in this paper where details of the formation can be seen in outcrop. Sections 20 and 21 combined as suggested on p. 107 are designated as the type. The thickness there exposed is about 300 ft. (292 ft. 6 in.).

Between Anglesea and Torquay the Coal Measures have been penetrated by several bores. The information thus available is summarized hereunder:

ANGLESEA. South Australian Oil Wells No. 1 bore, Parish of Angahook, proved a minimum thickness of 274 ft. below 188 ft. from surface and No. 2 bore a minimum thickness of 162 ft. below 580 ft. from surface. There is no evidence that either bore reached the Jurassic. Three seams of brown coal were reported in No. 1 bore and two in No. 2 bore. Logs of these bores are held in the office records of the Mines Department of Victoria.

POINT ADDIS. Bore No. 6, Parish of Jan Juc, proved 133 ft. of the Eastern View Coal Measures below 708 ft. 1 in. The driller's log is:

ft.	in.	
1	2	Shale, brown ligneous* (probably coal seam, cf. Jan Juc No. 5 Bore).
19	0	Sand, fine fossiliferous, pyritic.
2	0	Sand, cemented.
3	0	Shale, brown ligneous* (probably coal seam, cf. Jan Juc No. 5 Bore).
60	3	Sand, fine, hard cemented, pyritic with mica.
38	6	Sand, cemented.
1	0	Sand cemented with very hard band.
9	0	Sand, drift.
133	11	

*Should be "lignitic"; "ligneous" has an entirely different meaning.

BIRD ROCK-TORQUAY. The Coal Measures can be identified in the logs of Jan Juc Bores Nos. 2-5 (D.M.V. 1938). They proved the following thicknesses:

No. 2 — 79 ft. — top at 807 ft.
No. 3 — 134 ft. — top at 708 ft.
No. 4 — 112 ft. — top at 603 ft.
No. 5 — 102 ft. — top at 592 ft.

The driller's log of No. 3 Jan Juc is almost word for word a repetition of the log of No. 6 quoted above. Two seams of brown coal were logged in No. 2 and No. 5 bores and one in No. 4.

At Coalmine Creek the Coal Measures can be seen in close proximity to the underlying Jurassic bedrock. Krausé (1874) shows a small angular unconformity between the two (see p. 106) but the differences in dip and strike which he records are no greater than the differences observed between outcrops of Jurassic rocks in the neighbourhood. If there is an angular unconformity at this locality it can only be slight. Examination of the nearby outcrops and of air photographs suggests that the Tertiary and Jurassic beds are conformable, or nearly so, for at least six miles east of Coalmine Creek. In air photographs the Eastern View-Jurassic contact can be identified from the beach near the mouth of Spout Creek through Coalmine Creek at 0·4 mile from its mouth, in Mogg's Creek at 0·8 mile from its mouth to "The Glen", thence up the bed of Distillery Creek and beyond in a general north-easterly direction as far as Anglesea River. Parallel to this the outcrop of the silty sandstone near the base of the Demon's Bluff Formation (which crops out near the Mogg's Creek bridge—see p. 108) can be traced from Mogg's Creek to a point about one mile north-east of Painkalac Creek.

A clear contact between the Coal Measures and the Boonah Sandstone has not been seen, but the similarity in the lithology of the two formations suggests a gradational relationship.

Boonah Sandstone

This formation is defined as the sandstone between the top of the Eastern View Coal Measures and the base of the Demon's Bluff Formation, i.e. between the top seam of the Coal Measures at Eastern View and the siltstone with *Cyclammina* at Mogg's Creek; these are the only outcrops known. The thickness of the Sandstone in this locality is estimated to be not more than 1,200 ft. The name of the formation is taken from the name of the parish in which the outcrops occur.

It is thought that the whole of the formation is much like the partial section (No. 23) exposed at the top of the hill behind the Eastern View Hotel. Most of the sandstone is loosely cemented and this no doubt accounts for the fact that it makes poor outcrops.

The logs of the many bores drilled at Anglesea and Torquay are not sufficiently detailed to enable the Boonah Sandstone to be identified. Chapman and Singleton (1925) noted *Cyclammina* in a sample from Jan Juc No. 3 bore only 68 ft. above the highest coal seam, so that the formation, if present, is evidently much thinner at Torquay than at the type locality.

Demon's Bluff Formation

The Demon's Bluff Formation is defined as the sediments and volcanic rocks between the top of the Boonah Sandstone and the base of the Jan Juc Formation. It consists chiefly of siltstone, greywacke, minor loosely cemented coarse ferruginous quartz sandstone, and layers of thin beds of quartz pebbles. At Anglesea and Airey's Inlet volcanic rocks are interbedded with the uppermost sediments. The sediments range in colour chiefly from brownish black to red-purple, and they usually are characterized by abundant filled worm burrows and algal (?) remains. Almost any sample from the main part of the Formation contains *Cyclammina* and this foraminifera commonly occurs in great abundance. Other fossils are scarce.

The only complete natural section is provided by the exposures between Mogg's Creek and Airey's Inlet in the Parish of Boonah (Sections 22 to 24), but the best-known partial sections are in the Parish of Angahook (Sections 1 to 3). Measurements made in the type locality suggest that the Formation has a thickness of about 1,300 ft. The records of boring at Anglesea, Point Addis and Torquay indicate that the Formation maintains the lithological features observed in outcrop over the whole coastal strip described in this paper. These borings also provide some useful information on the thickness of the Formation.

In referring to the Jan Juc Nos. 1-5 bores Chapman and Singleton (1925, p. 996) state:

> "At Torquay recent borings in search of oil prove the deepest beds yet reached to consist of lignitiferous sands with the foraminifera *Cyclammina*; the range of this series, from the data at present available, being approximately between 840 and 410 feet below sea-level. At a depth of 170 feet below sea-level the beds consist of the typical greensands and marls which are exposed in the Bird Rock cliffs. An earlier boring near Bird Rock penetrated this latter series to a depth of 70 feet, and a detailed examination of the material by one of us (F.C.) showed no notable variation from the fauna and lithology of the Bird Rock series."

From investigation in the field and examination of bore data it was apparent that there must be errors in this statement.

We are indebted to Mr. W. Baragwanath and Dr. D. E. Thomas who, by searching Victorian Mines Department records, have cleared up the doubtful points. These records show that the bore referred to is No. 3 and that the statement should be corrected as follows:

> "At Torquay . . . ; the range of this series, from the data at present available, being approximately between *640* and 410 ft. below *the surface at No. 3 bore*. At a depth of 170 ft. *in this bore* the beds consist of the typical greensands and marls which are exposed in the Bird Rock cliffs."

This note by Chapman and Singleton shows that the top of the Demon's Bluff Formation was intersected between 170 ft. and 410 ft. in No. 3 bore and its minimum thickness is therefore about 230 ft.; actual thickness may be 320 ft. (See Fig. 4.)

The logs of the Point Addis bores (Jan Juc 6 and 7) provide some information on the thickness of the Formation. Taking into account its position in relation to the cliff exposures nearby, No. 6 bore could not have penetrated much more than 115 ft. of the strata overlying the Demon's Bluff Formation and possibly its top immediately underlies the bed designated "limestone band, hard", logged at 140 ft. This bore intersected the top of the Eastern View Coal Measures at 708 ft., so that the thickness of the Demon's Bluff Formation plus the Boonah Sandstone is not greater than 568 ft.

No. 7 bore would have passed into the top of the Demon's Bluff Formation at about sea-level. Its collar is about 70 ft. above sea-level so that possibly the bore entered the Formation at 91 ft.—"Sand, cemented". If so, this bore was in either the Demon's Bluff or the Boonah Sandstone for a bore depth of at least 600 ft. (a true thickness of 580 ft.).

The two bores put down by South Australian Oil Corporation Limited at Anglesea provide useful information. Logs were made available for examination by courtesy of the Company and the Victorian Mines Department. The horizon at which No. 2 bore commenced cannot be determined reliably, but the log suggests that it commenced in the Demon's Bluff Formation (it was certainly in the Formation at 40 ft.) proving a thickness for the Demon's Bluff Formation plus the Boonah Sandstone of not less than 580 ft. At 366-439 ft. the driller logged "brown clay—beds of fossil shells" and at 446-472 ft. "more fossils". Among the fossils found at 366-439 ft. F. Chapman identified *Jouanetta cuneata* and *Turritella* sp. This is an unusual record, as shelly fossils are extremely scarce in the outcrops of the Demon's Bluff Formation. The shells identified by Chapman cannot be found.

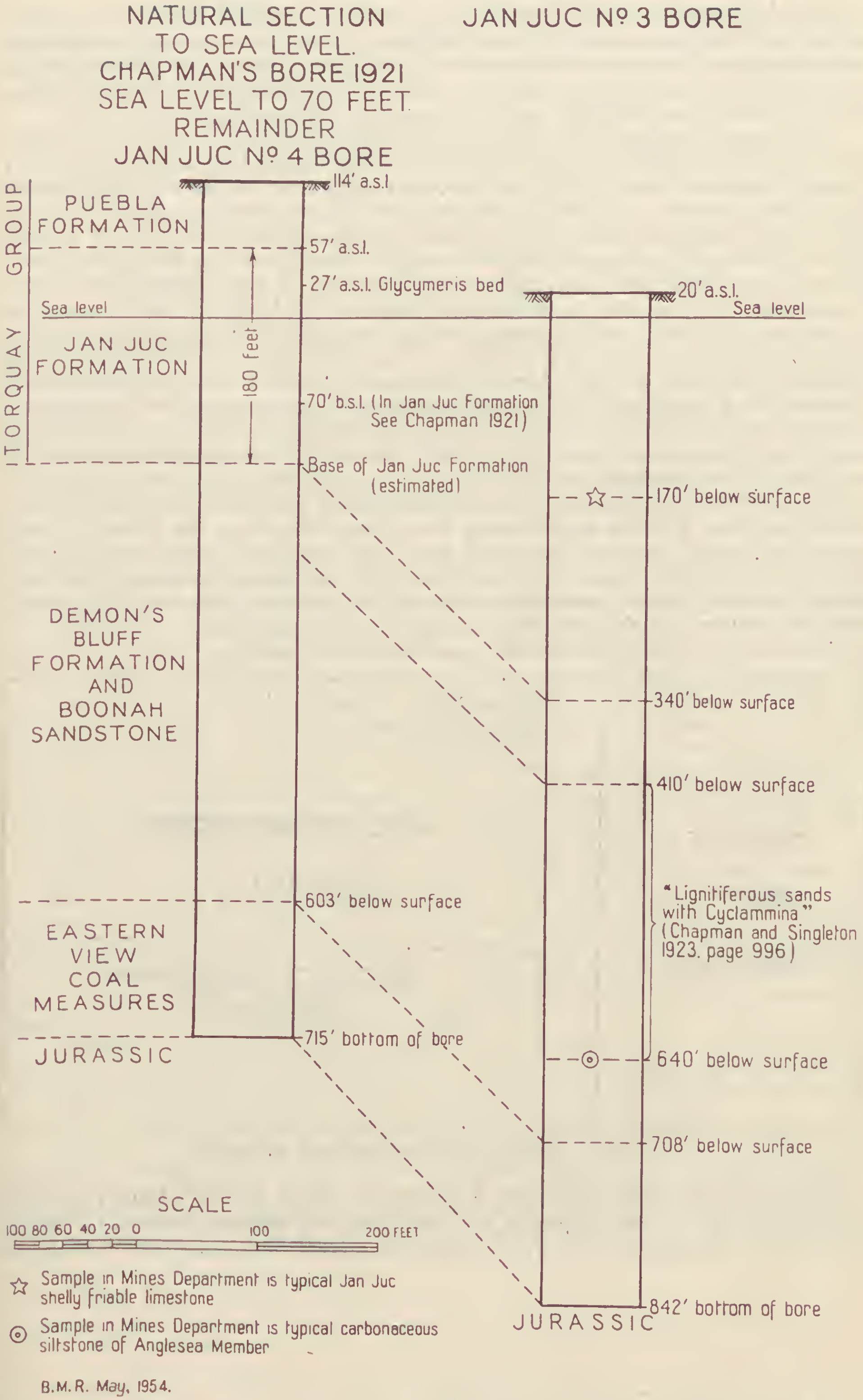

NATURAL SECTION
TO SEA LEVEL.
CHAPMAN'S BORE 1921
SEA LEVEL TO 70 FEET
REMAINDER
JAN JUC Nº 4 BORE
JAN JUC Nº 3 BORE
TORQUAY GROUP
PUEBLA FORMATION
JAN JUC FORMATION
DEMON'S BLUFF FORMATION AND BOONAH SANDSTONE
EASTERN VIEW COAL MEASURES
JURASSIC
114' a.s.l.
57' a.s.l.
27' a.s.l. Glycymeris bed
Sea level
180 feet
70' b.s.l. (In Jan Juc Formation See Chapman 1921)
Base of Jan Juc Formation (estimated)
603' below surface
715' bottom of bore
20' a.s.l.
Sea level
170' below surface
340' below surface
410' below surface
"Lignitiferous sands with Cyclammina" (Chapman and Singleton 1923. page 996)
640' below surface
708' below surface
842' bottom of bore
JURASSIC
SCALE
100 80 60 40 20 0 100 200 FEET
☆ Sample in Mines Department is typical Jan Juc shelly friable limestone
⊙ Sample in Mines Department is typical carbonaceous siltstone of Anglesea Member
B.M.R. May, 1954.

FIG. 4.—Correlation between Chapman's Bore (1921), Jan Juc No. 3 and Jan Juc No. 4 Bores.

Between Anglesea and Bell's Headland the Demon's Bluff Formation consists of two well-defined members (described below). These are essentially greywacke and siltstone ranging from deep brownish black at the base through pale red-purple to yellowish grey at the top. The colour is due to finely divided organic (carbonaceous) matter, most of which can be removed by repeated washing.

The volcanic agglomerate and coarse sandstone (exposed between Urquhart's Bluff and Airey's Inlet) and the volcanic rocks and interbedded sediments exposed at and adjacent to Soapy Rock, Anglesea, are included as a member of the Demon's Bluff Formation for the following reasons. The volcanic rocks are known to occur only over a limited area and are interbedded with sediments which have a lithological affinity with the underlying beds and are sharply distinguished from those above. The volcanic rocks and the sediments with which they are associated were deposited at the same time as marine sediments of the Demon's Bluff Formation.

Reference is made to the contact of the Demon's Bluff Formation with the Boonah Sandstone on p. 113. At the only clear exposure of the contact of the Demon's Bluff and the Jan Juc Formations at Addiscot near Bell's Headland (Section 5) it is gradational. It is impossible to be quite sure of the stratigraphic position of the sediments and volcanic rocks at the top of the Formation at Anglesea, and of the volcanic rocks between Airey's Inlet and Urquhart's Bluff, relative to the passage beds at Addiscot. The presence of coarse sands in erosion hollows in the agglomerate and of volcanic breccia interbedded with the Demon's Bluff sediments indicates that the agglomerate should be referred to the Demon's Bluff Formation, so that at Airy's Inlet there were apparently some minor vertical movements immediately prior to the deposition of the overlying limestones; however, there is certainly nothing more than erosional disconformity between the Demon's Bluff Formation and the overlying limestones at this locality.

The Demon's Bluff Formation is sub-divided as under:

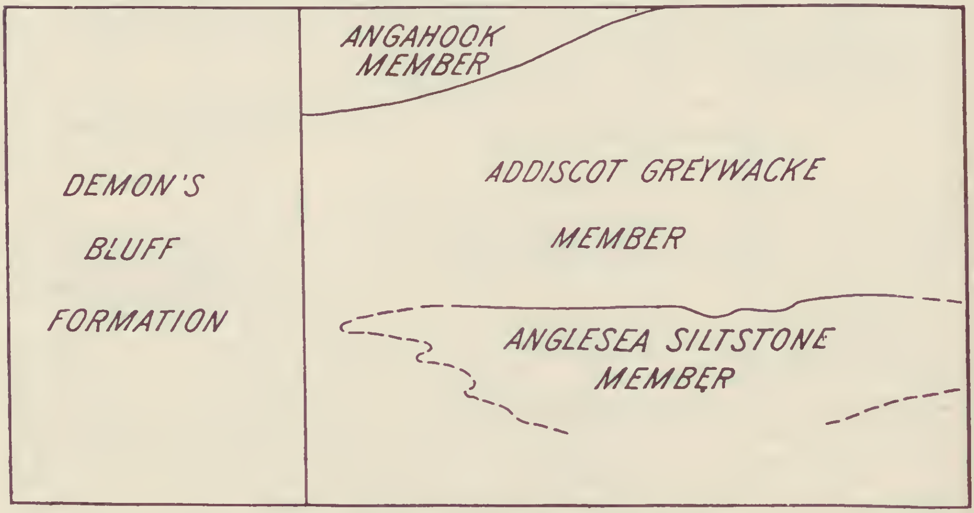


Fig. 5.—Subdivision of Demon's Bluff Formation.

Anglesea Siltstone Member. This member of the Demon's Bluff Formation is defined as the brownish black *Cyclammina*-bearing siltstone between the top of the Boonah Sandstone and the pale red-purple greywacke (Addiscot Member) of the Demon's Bluff cliffs, the cliffs near the Black Rocks, Point Addis, Jarosite Headland and Addiscot. These are the beds which form the lower part of the cliffs at Demon's Bluff to which Singleton (1941, p. 25) in a strict lithological sense, originally applied the name "Anglesean".

Some details concerning the Anglesea Member are given in—

Section	Samples	Thickness ft.
1	E.1 to E.6	48+
2	W.1 to W.3	19+
Jarosite Headland	—	35+
5	B.106	37+

and in the palaeontological notes on those sections.

The Anglesea Member has a remarkably homogeneous lithology. It is a siltstone, arkosic in places, coloured brownish black and characterized everywhere by filled worm burrows and algal (?) remains (Glover, 1954; Dallwitz, 1954). Reference is made to its characteristic lithology and jointing on pp. 84 and 90.

No section is known which reveals the base of the Anglesea Member and the bore logs are not sufficiently detailed to give any information about the contact.

The contact between the Anglesea and Addiscot Members is well exposed in several places and reference has been made thereto on pp. 84, 85 and 92. In some places the passage is gradational; in others there is disconformity between the two. This disconformity was due to minor local movements; the sediments below and above it differ little in lithology and the ecological conditions were unchanged. Slight as are the measurable differences between them, the members show out in striking contrast on weathering—the joint surfaces in the Anglesea Member commonly do not pass into the Addiscot Member; bedding planes are difficult to identify in the Anglesea Member but show out clearly in the Addiscot Member. The Anglesea Member is regarded as a carbonaceous (lignitic) lens in the Demon's Bluff Formation. Its westerly limit is somewhere between Anglesea and Mogg's Creek, but its eastern and other limits are not known. It extends east at least as far as Bird Rock; the sample in the Mines Department from a depth of 640 ft. in No. 3 Jan Juc bore is typical of the member. (See Plate IV, fig. 3; Plate V, fig. 1.)

ADDISCOT (GREYWACKE) MEMBER. This Member in the type cliff section at the eastern end of Addiscot Beach includes all the beds between the top of the Anglesea Member and the Jan Juc Formation. On the west side of Anglesea River and between Urquhart's Bluff and Airey's Inlet, volcanic rocks and sediments (Angahook Member) occur between the top of the Addiscot Member and the Jan Juc Formation. The type section is No. 5, from the erosion surface above sample B.106 to B.110 inclusive; thickness 64 ft.

A complete section is exposed also on the west side of the Anglesea River—Section 3—from the erosion surface below W.4 to W.11 inclusive; thickness 73 ft.

Partial sections are exposed between Anglesea River and Addiscot. See Section 1 (56 ft.); Section 4 (40+ ft.), and general notes on pp. 90 and 92.

Except for a lightening in colour towards the top the Addiscot Member is as remarkably homogeneous as the Anglesea Member. In fact it resembles this Member closely in everything but colour; it is slightly coarser in grain than the Anglesea Member and hence has been designated greywacke rather than siltstone. A petrological description is given by W. B. Dallwitz (1954).

The section at Addiscot shows gradual passage from the Addiscot Member to the Jan Juc Formation. Between Anglesea and Airey's Inlet, however, there was apparently a change from marine to fluviatile conditions which coincided with volcanic activity. After the volcanic episode there was some erosion and deposition of coarse sands before the overlying limestones (Point Addis Member) were deposited.

ANGAHOOK MEMBER. This Member is named after the Parish of Angahook in which the best section occurs—Section 3 above the top of W.11 (see also Plate IV, fig. 2).

At the type locality the Angahook Member is 70 ft. thick. The lower half consists of alternations of shale with volcanic breccia and agglomerate; the upper half consists predominantly of poorly bedded claystone and fine sandstone. The bottom bed of the Member is a thin seam of brown coal and most of the lower half consists of sediments deposited in fresh water, but the presence of coprolites associated with pebbles of basalt about the middle of the Member shows reversion to marine conditions. For details see Section 3.)

At Airey's Inlet the Angahook Member is represented by about 50 ft. of volcanic rocks, dominantly coarse agglomerate, overlain disconformably by calcarenites of the Point Addis Member. In one place—¼ mile north of Eagle Rock—twelve feet of well-bedded coarse quartz sandstone occurs between the agglomerate and the calcarenite. (For details see pp. 104 and 105.)

The Angahook Member is represented at Point Addis by about 50 (43) ft. of unfossiliferous sediments (between PA.1 and PA.6 of Section 4). Though poorly exposed these sediments are like those in the type section except that they apparently do not include volcanic rocks. At Point Addis the upper disconformable contact of the Angahook Member with the Point Addis Member closely resembles the section at Airey's Inlet.

West of Airey's Inlet the Angahook Member consists of the unfossiliferous coarse sandstone and clays exposed at the bridge over Airey's River (Painkalac Creek) and similar beds in Section 24. Volcanic clay (ashstone) occurs interbedded with the sandstone in Section 24.

The Member cannot be identified at the eastern end of Addiscot Beach where there is an almost continuous section from the upper beds of the Demon's Bluff Formation to the Jan Juc Formation. Somewhat arbitrarily it may be said that it is represented in this Section by B.110—6 ft. of unfossiliferous brown and yellow sandstone—but it is more probable that deposition of marine sediments was taking place continuously at Addiscot while freshwater sediments were being deposited elsewhere.

Details of the sections exposed in the cliffs eastward from Split Point are given on pp. 104, 105. Reference is made to the Urquhart's Bluff agglomerate and the overlying clays on p. 104, where also correlation with the upper part of Section 3 at Anglesea is discussed. Details of the Angahook Member as exposed west of Anglesea River are included in Section 3, samples W.12 to W.102 inclusive, thickness 69+ ft.

The lower contact of the Member is not seen at Split Point. West of Anglesea this contact is marked by a sharp change in lithology corresponding with a change from the marine conditions in which *Cyclammina* flourished to freshwater conditions. The upper contact is described on pp. 88 and 89.

MICROPALAEONTOLOGY OF DEMON'S BLUFF FORMATION. The most striking feature of the microfaunal assemblage in the lignitic silts and greywackes of the Demon's Bluff Formation is the uniformity of genera and species of foraminifera, which in turn indicates uniformity of bathymetric and climatic conditions at the time of deposition. The foraminiferal assemblage consists of the arenaceous genera *Ammodiscus, Bathysiphon* and *Cyclammina*. Small fragments of bryozoa and valves of thin-shelled ostracoda are rarely present. *Cyclammina* dominates the assemblage and in many of the samples examined it is present to the exclusion of all other forms. *Ammodiscus, Bathysiphon* and *Cyclammina* are benthonic foraminifera, and recent investigations indicate that these forms thrive in stagnant, marine waters as well as in deep water. According to Lowman (1949) the assemblage *Cyclammina-Bathysiphon* is found in some deposits in which the mineral and plant components suggests a low oxygen content. He states further that these two arenaceous genera together with certain other benthonic forms will "tolerate conditions that normal assemblages do not tolerate".

It seems, therefore, that the Demon's Bluff Formation was laid down in almost stagnant water in which plant remains were common and into which tides floated such neritic forms as *Dorothia* and *Cibicides* as well as bryozoa and ostracoda.

The foraminifera recognized in the Formation are as follows:

Ammodiscus incertus (d'Orb.) var. *macilenta* Chapman
Ammodiscus cf. *parri* Crespin
Bathysiphon angleseaensis Crespin
Cibicides cf. *umbonifer* Parr
Cyclammina incisa Stache (abundant)
Cyclammina paupera Chapman (common)
Cyclammina rotundata Chapman and Crespin (common)
Cyclammina sp. (small species and very common)
Dorothia cf. *parri* Cushman
Lituola simplex Chapman
Rhabdammina sp.

Cyclammina is very abundant in the purplish greywacke which forms the upper part of the Demon's Bluff Formation (Addiscot Member) in the vicinity of Demon's Bluff, east of Anglesea, which Singleton (1941) regarded as unfossiliferous. The tests, some of which have a diameter of 4 to 5 mm., are better preserved in these beds than in the underlying lignitic siltstone (Anglesea Member). However, the greatest number of individual tests in any one sample came from Sample E.2 in Section 1, near the top of the Anglesea Member, in which 64 complete tests were counted.

Cyclammina is represented by three species, *C. incisa, C. paupera* and *C. rotundata. C. incisa* (Plate VII, fig. 3) was described by Stache (1864) from beds in New Zealand now regarded as Lower Oligocene, and it has been recorded from the Upper Eocene in the Perth bores, Western Australia. *C. paupera* (Plate VII, fig. 4) was described by Chapman (1904) from beds at Brown's Creek, 50 miles south-west of Anglesea, which lithologically closely resemble the Demon's Bluff Formation and are similar in age. However, another species, *C. complanata,* also described by Chapman, from Brown's Creek, has not been found in the Torquay-Anglesea area. *C. rotundata* (Plate VII, figs. 5a, 5b) was described by Chapman and Crespin ((1930b) from marls of "Janjukian" age at the depth of 1,295 ft. in No. 1 Bore, Parish of Bumberrah Metung), Gippsland.

The rich *Cyclammina*-bearing beds of the Anglesea area are known to extend westward to south-eastern South Australia and eastward to Gippsland in south-eastern Victoria. This type of deposit, which boring has shown to be of considerable thickness, seems to be confined to the Tertiary of south-eastern Australia.

Ammodiscus is moderately common in the siltstones of the Demon's Bluff Formation but the tests are usually fragmentary. *Ammodiscus incertus* var. *macilenta* is recorded; this variety was described by Chapman (1904) from Brown's Creek. Fragments of large tests are referred to *A. parri* (Plate VII, fig. 2) described by Crespin (1950). One complete but poorly preserved test from the cliffs immediately west of The Black Rocks measures 4 mm. in diameter. A large species most probably referable to this form is fairly common in beds of Janjukian age in bores in Gippsland.

Bathysiphon angleseaensis (Plate VII, fig. 1) was described by Crespin (1950) from sample E.8 which came from 5-10 ft. above the base of the Addiscot Member at Demon's Bluff (Section 1). The species is fairly common in samples from the Demon's Bluff cliff.

Both large and small tests of the genus *Dorothia* are present fairly generally. The larger ones are referred to *D. parri* Cushman. The smaller ones, though common, are too poorly preserved for specific determination.

The only calcareous genus noted is a small *Cibicides* which is similar to a species *C. umbonifer* described by Parr (1938) from beds in the King's Park bore, Perth, Western Australia, which he referred to the Upper Eocene.

Torquay Group

This Group is defined as including all the beds between the top of the Demon's Bluff Formation and the top of the limestone which forms the cliffs between Bird Rock and the mouth of Spring Creek (Zeally Limestone Member). Torquay is the name of the largest village in the area described which is commonly referred to as the Torquay district. No single lithological term describes the group adequately. Two formations may be recognized, the plane of division being at the top of marker "F" in Section 7 (Bird Rock Bluff).

From the Bird Rock Bluff to the locality FD., about midway between Fisherman's Steps and Dead Man's Gully, the lower formation is a shelly friable calcarenite with poorly defined stratification. Shelly fossils are present in abundance and glauconite pipes are common. Westerly from locality FD., massive non- or poorly-fossiliferous calcilutite beds from 1 to 3 ft. in thickness occur. Gradually, however, as traced westerly to Bell's Headland almost the whole of the exposed portion of the Formation is composed of a tough calcarenite (Point Addis Limestone Member), lithologically like the Zeally Limestone Member, with which it has been, incorrectly, correlated. Judging by exposures immediately west of Bell's Headland and the records of bores near Bird Rock, the lower portion of the Formation is sandy and shelly between these points. Between Bell's Headland and Point Addis the lower sandy, shelly beds die out and the Point Addis Member is in contact with the Demon's Bluff Formation. At Airey's Inlet all the post-Demon's Bluff beds exposed are limestone (calcarenite)—tentatively included in the Point Addis Member.

The upper formation maintains a fairly uniform lithology westerly from Bird Rock Point. It consists of marl passing up into siltstone, has well-defined stratification and contains some thin but distinct marker beds of silty limestone (calcilutite). Easterly from Bird Rock Point the Formation shows a marked and abrupt change to the dominantly calcarenitic Zeally Limestone Member. Compared with the lower Formation it has a sparse mega-fauna.

Details of the lithology of the Group are given in the description of Sections 4-19 inclusive and in Fig. 7. The greatest thickness of the Group—216 ft.—is exposed in cliff sections from a point about midway between Fisherman's Steps and Bird Rock (Section 9) to Torquay (Section 18). However, the base is not exposed in this area. The bore reported upon by Chapman (1922a) proved an additional 70 ft. of sandy, shelly glauconitic marls below the natural exposures (Section 9) and it is estimated that about another 50 ft. was proved by the Jan Juc Nos. 1-5 bores (D.M.V. 1938) giving a total thickness of about 340 (336) ft. The 50 ft. estimate is based on the following argument. Jan Juc No. 4 bore was well placed to prove the Tertiary sequence (and, incidentally, to test the oil possibilities of the anticlinal structure between Bird Rock and Fisherman's Steps). It was put down at a point—elevation 114 ft. above sea-level—almost vertically above the 70 ft. bore (Chapman 1922a; Section 9) and passed through flat-lying beds at the crest of a symmetrical anticline; bore thicknesses are therefore true thicknesses. The driller's log is not much use for stratigraphical purposes. The bore could not have reached the Demon's Bluff Formation above 211 ft.—114 plus 97 (Section 9)—but 32 ft. of "sandy ligneous clay" is logged at 106 ft.; possibly this represents the grey marl (Marker "G") in the Bird Rock Section (Section 7). By drawing correlation lines between bores No. 3 and 4 and using the information available concerning No. 3 bore (see p. 114) it seems reasonably certain that the bottom of the 70 ft. bore was within 125 ft. or less of the top of the Demon's Bluff Formation (see Fig. 4). Inspection of the logs of the bores themselves suggests that the bottom of the 70 ft. bore was possibly about 50 ft. from the top of the Demon's Bluff Formation. However, this is only an informed guess. This correlation incidentally shows that the core from a depth of 170 ft. in No. 3 bore examined by Chapman and Singleton (1925) came from about the top of the lower shelly part of the Group and was therefore stratigraphically higher (not lower, as Chapman and Singleton thought) than the beds proved by the 70 ft. bore (see pp. 82 and 114, and Fig. 4).

At Bell's Headland (Section 5), Point Addis (Section 4) and Airey's Inlet (Section 19) the base of the Group is exposed and the thicknesses are respectively 159, 92 and 75 ft. At these localities, however, it is impossible to determine how much of the upper beds has been removed by erosion.

The relationship of the Torquay Group to the Demon's Bluff Formation is described on p. 116; its relationship to the next succeeding formations is not revealed by any section in the area described in this paper but some deductions can be made concerning it on palaeontological evidence (see p. 125).

The Torquay Group is subdivided as illustrated in Fig. 6.

Jan Juc Formation

The Jan Juc Formation is defined as that part of the Torquay Group below the top of marker "F" in Section 7 at Bird Rock Point. At the type locality (Sections 7 and 9) the exposed section of the Formation consists of 57 ft. of friable calcarenite with a great abundance of shelly fossils and a considerable amount of glauconite. (See Glover, 1954, for notes on glauconite.) By reference to Sections 7-11 in Fig. 7 and the discussion above it is apparent that the known thickness of the Formation at the type locality, including the beds proved by the 70 ft. bore (Section 10), is 129 ft., and that its probable total thickness is about 180 ft.

Bird Rock Point is regarded as the type locality because it is the best known. The most complete section, however, is exposed on the western side of Bell's Headland and in the low cliffs at the eastern end of Addiscot Beach.

The Formation is not exposed east of Bird Rock; south-westerly from Bird Rock its upper part is continuously exposed for two miles. As noted on page 120 from locality FD. westerly a facies change is apparent.

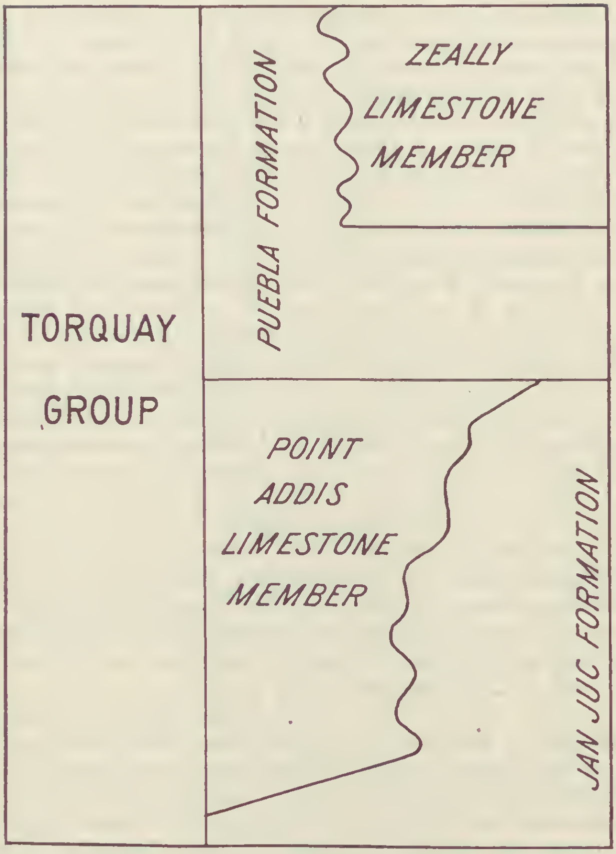
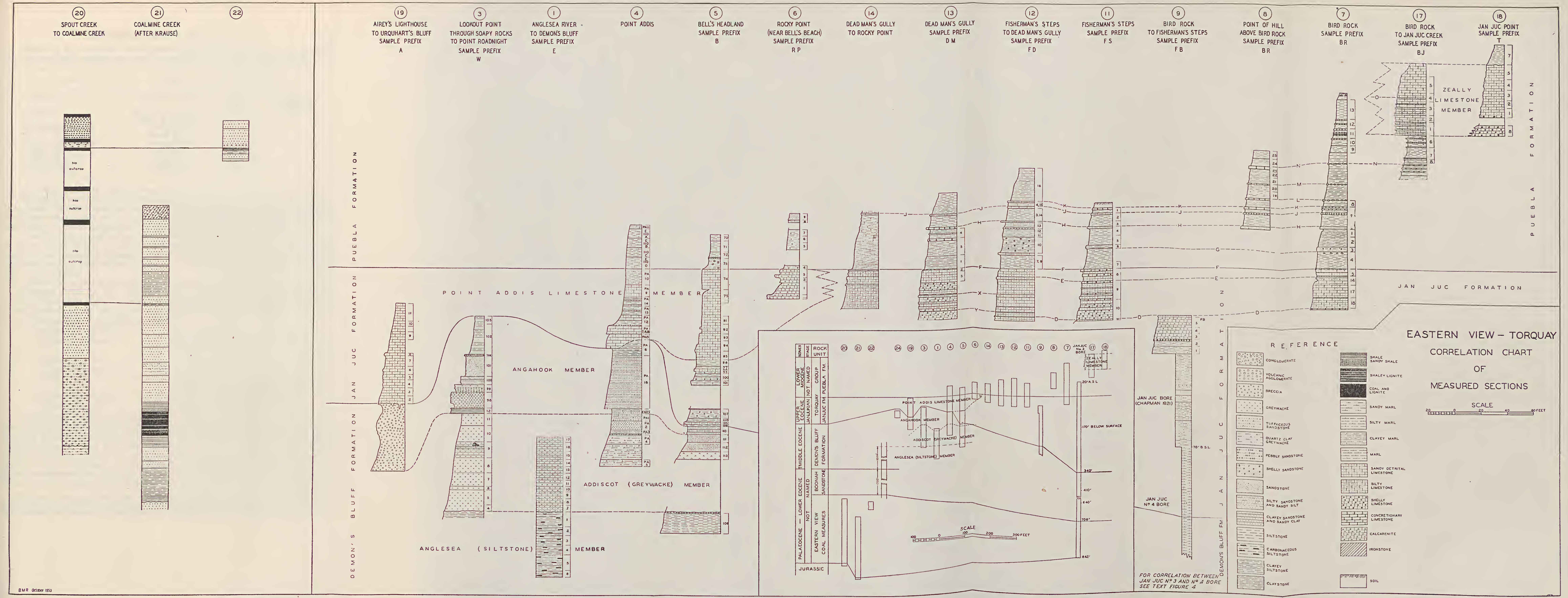


FIG. 6.—Subdivision of Torquay Group.

The top of the Jan Juc Formation at Bird Rock is a well-cemented calcilutite (Marker "F") from a few inches to 2 ft. in thickness, lenticular in places but almost continuous to a point about midway between Fisherman's Steps and Dead Man's Gully. From that point westerly, although the boundary between the Formation and the overlying beds is distinct, this particular marker loses its identity. Another well-marked similar bed "E" forms the top of the small stack known as Bird Rock. This marker dies out a few hundred feet east of Dead Man's Gully. The lower part of the beds exposed at Bird Rock and Fisherman's Steps is characterized by a great abundance of the pelecypod *Glycymeris ornithopetra* Chapman and Singleton. One bed ("D"), composed largely of these shells, although only about 9 in. thick, forms a persistent horizon marker from Bird Rock to locality FD. (Section 12). *Glycymeris* is common west of this locality but the marker "D" peters out about 100 ft. east of Dead Man's Gully. This part of the section passes below sea-level 100 ft. west of Dead Man's Gully and where it is exposed farther west at Bell's Headland it is in limestone facies and *Glycymeris* is not present. The lower sandy beds at Bell's Headland contain very large numbers of gastropods.



EASTERN VIEW – TORQUAY
CORRELATION CHART
OF
MEASURED SECTIONS
SCALE
20 0 20 40 60 FEET
(20) SPOUT CREEK TO COALMINE CREEK
(21) COALMINE CREEK (AFTER KRAUSE)
(22)
(19) AIREY'S LIGHTHOUSE TO URQUHART'S BLUFF SAMPLE PREFIX A
(3) LOOKOUT POINT THROUGH SOAPY ROCKS TO POINT ROADNIGHT SAMPLE PREFIX W
(1) ANGLESEA RIVER - TO DEMON'S BLUFF SAMPLE PREFIX E
(4) POINT ADDIS
(5) BELL'S HEADLAND SAMPLE PREFIX B
(6) ROCKY POINT (NEAR BELL'S BEACH) SAMPLE PREFIX RP
(14) DEAD MAN'S GULLY TO ROCKY POINT
(13) DEAD MAN'S GULLY SAMPLE PREFIX DM
(12) FISHERMAN'S STEPS TO DEAD MAN'S GULLY SAMPLE PREFIX FD
(11) FISHERMAN'S STEPS SAMPLE PREFIX FS
(9) BIRD ROCK TO FISHERMAN'S STEPS SAMPLE PREFIX FB
(8) POINT OF HILL ABOVE BIRD ROCK SAMPLE PREFIX BR
(7) BIRD ROCK SAMPLE PREFIX BR
(17) BIRD ROCK TO JAN JUC CREEK SAMPLE PREFIX BJ
(18) JAN JUC POINT SAMPLE PREFIX T
No outcrop
No outcrop
No outcrop
PUEBLA FORMATION
JAN JUC FORMATION
DEMON'S BLUFF FORMATION
DEMON'S BLUFF FM
POINT ADDIS LIMESTONE MEMBER
ANGAHOOK MEMBER
ADDISCOT (GREYWACKE) MEMBER
ANGLESEA (SILTSTONE) MEMBER
ZEALLY LIMESTONE MEMBER
JAN JUC BORE (CHAPMAN 1921)
JAN JUC Nº 4 BORE
70' B S.L.
FOR CORRELATION BETWEEN JAN JUC Nº 3 AND Nº 4 BORE SEE TEXT FIGURE 4
SERIES
STAGE
ROCK UNIT
LOWER MIOCENE
UPPER EOCENE
?MIDDLE EOCENE
PALAEOCENE — LOWER EOCENE
JURASSIC
NOT NAMED
JANJUKIAN
NOT NAMED
TORQUAY GROUP
PUEBLA FM.
JANJUC FM.
DEMON'S BLUFF FORMATION
BOONAH SANDSTONE
EASTERN VIEW COAL MEASURES
(20) (21) (22) (24) (19) (3) (1) (4) (5) (6) (14) (13) (12) (11) (9) (8) (7) JANJUC No 3 BORE (17) (18)
20' A.S.L.
170' BELOW SURFACE
340'
410'
640'
708'
842'
1200'
SCALE
100 0 100 200 300 FEET
REFERENCE
CONGLOMERATE
VOLCANIC AGGLOMERATE
BRECCIA
GREYWACKE
TUFFACEOUS SANDSTONE
QUARTZ CLAY GREYWACKE
PEBBLY SANDSTONE
SHELLY SANDSTONE
SANDSTONE
SILTY SANDSTONE AND SANDY SILT
CLAYEY SANDSTONE AND SANDY CLAY
SILTSTONE
CARBONACEOUS SILTSTONE
CLAYEY SILTSTONE
CLAYSTONE
SHALE SANDY SHALE
SHALEY LIGNITE
COAL AND LIGNITE
SANDY MARL
SILTY MARL
CLAYEY MARL
MARL
SANDY DETRITAL LIMESTONE
SILTY LIMESTONE
SHELLY LIMESTONE
CONCRETIONARY LIMESTONE
CALCARENITE
IRONSTONE
SOIL
BMR October 1953

Fig. 7.—Eastern View - Torquay; Correlation Chart of measured Sections.

1

Details of the formation and additional notes on the changes in its lithology are given in earlier pages and may be identified from east to west as under:

Sections	Samples	Thickness ft.	in.
7 Bird Rock	BR.5 down to BR.18	29	6 (Exposed
		180	(Estimated)
9 and 10	FB.1-5 (27 ft. 5 in.) plus 70 ft. bore	97+	
11 Fisherman's Steps	FS.8-11	39+	
12	Below FD.1	38+	
13 Dead Man's Gully	Below DM.1	36+	
6 Rocky Point	RP.1-3	22+	
5 Bell's Headland	B.74-B.109	112	
4 Point Addis	PA.10-PA.15	60	
19 Airey's Inlet	A.2-A.11	75+	

The facies change are summarized in Fig. 7.

The contact of the formation with the overlying beds has been described above; it is sharp but concordant and evidently marks a significant change in conditions of sedimentation expressed by change in lithology, reduction in shelly fossil content, and reduction in the development of glauconite. (See Plates V and VI.)

There is a great deal still to be discovered about the origin of glauconite but it seems agreed that it is a product of diagenesis* and an index of slow, even negative, sedimentation (Hadding, 1932; Shephard, 1948; Twenhofel, 1932), an inference supported by the presence of at least one wave cut platform in the Jan Juc Formation.

The contact with the Demon's Bluff Formation is discussed on pp. 92 and 116.

Pritchard (1925, p. 155) suggested that seven sets of beds characterized by certain mega-fossils could be recognized in what is defined in the present paper as the Torquay Group. By reference to Singleton's comments (1941, p. 39) they may be approximately identified as follows:

Scutellina limestone	Zeally Member at Jan Juc Point.
Cellopora limestone	Zeally Member between Jan Juc Creek and Bird Rock.
Ancilla Clays and Septarian Limestones	Puebla Formation in type section at Bird Rock.
Chione Clays	Top of Jan Juc Formation at Bird Rock Bluff between markers "E" and "F".
Glycymeris beds and *Limopsis* beds	Jan Juc Formation below marker "E".

Point Addis Limestone Member. The limestone facies of the Jan Juc Formation is designated the Point Addis Limestone Member and the type section is provided by the interval PA.15/PA.10 in Section 4 at Point Addis. The name "Addis Limestone" was first used—informally—for this Member by Hall (1910, p. 45). The word "Point" has been retained in the name so that it will not be confused with "Addiscot". A generalized description of the Member has been given in discussing the Torquay Group and the Jan Juc Formation and details are given in the description of the measured sections from west to east as under:

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*The larger masses of glauconite in the Jan Juc Formation obviously were formed in place. Some are parallel to the bedding, others are in the form of vertical pipes. Those parallel to the bedding are irregular in shape and could not have survived transportation.

Sections	Samples	Thickness (ft.)
19 Airey's Inlet	A.2-A.11	75+
4 Point Addis	PA.10-PA.15	60
5 Bell's Headland	B.74-B.94	62
6 Rocky Point	Below RP.4	22+

From these descriptions it will be noted that at Airey's Inlet and Point Addis the Member appears to represent the same stratigraphical interval as the Jan Juc Formation, but at Bell's Headland it represents only the upper part of that interval —60 ft. of sandy beds with a gastropod fauna occur between the base of the Member and the top of the Demon's Bluff Formation. Between Rocky Point and the locality of Section 14 the Member loses its identity; it passes into a number of thin beds of calcilutite interfingering with the loosely cemented shelly facies of the Jan Juc Formation.

The upper surface of the Member is not exposed at Airey's Inlet, but at all places where it is exposed it is in sharp contact with the Puebla Formation. The lower contact at Airey's Inlet is with agglomerate or coarse sand of the Angahook Member; at Point Addis with gritty clays of the same Member; at Bell's Headland with the sandy gastropod-bearing beds referred to above. The base is not exposed at Rocky Point.

Puebla Formation

The Puebla Formation is defined as that part of the Torquay Group above the top of the Jan Juc Formation.

Puebla is the old name for the village of Torquay and is the name of the parish north-east of the lower part of Spring Creek. A name more closely associated with the type locality would have been preferred, but such names are few and either unsuitable or pre-empted.

The type section is exposed at the Bird Rock Bluff and between the Bluff and the mouth of Jan Juc Creek—Section 7 above the top of Marker "F" and Section 17. At the type locality the Formation consists of marl and siltstone with six massive to concretionary beds of calcilutite each up to 2 ft. thick. East of the Bird Rock Bluff the upper part of the Formation changes sharply to calcarenite (Zeally Limestone Member).

The thickness of the Puebla Formation at the type locality is about 160 (158) ft. Details of the lithology are given in Sections 7 and 17 but notes on the outcrop of some of the more distinctive beds are given here in ascending sequence.

The lowest 10-15 ft. of the Formation are more clayey than most of the higher beds. Almost everywhere they have slumped, and clean outcrops are rare and transient. The next succeeding bed (e.g. FS.16) though not obviously different from those above it, makes a characteristic smoothly rounded outcrop convex outwards from the cliffs.

The foregoing is true of the sections between Bird Rock and locality RP.; west from there the lower beds are like the remainder of the Formation.

The calcilutite markers "H", "J" and "K", though generally similar, have individual characteristics. "H" is light olive grey in colour (5 Y 5/2) and is the most massive of the three. Because of this it stands out best; the soft beds below it slump away forming an inverted ledge. "J" is yellow, pitted and lenticular. "K" is grey, mottled yellowish brown; it is continuous but has a concretionary structure and roughly cubical jointing.

Westerly from Bird Rock only partial sections are exposed. They show lithological similarity with the type sections and many individual beds can be traced from place to place. At Fisherman's Steps the thickness exposed is 50 ft. The markers "H", "J" and "K" at the top of the section can be traced continuously from Bird Rock to Fisherman's Steps. At locality FD., 69 ft. of the Formation are exposed including the same three markers. The lithology of the beds at FD. is somewhat different from those east and west of it; they are darker in colour and at outcrop contain much gypsum. This change is also expressed in the microfauna. At Dead Man's Gully the section is 57 ft. thick and includes markers "H" and "J"; "K" dies out on the western side of FD.; "H" dies out west of Dead Man's Gully; "J" can be traced to a point 1,200 ft. west of Dead Man's Gully. Westerly from this point to Rocky Point the cliffs decrease in height and outcrops of the Formation are obscured by dense scrub. The partial sections exposed at Rocky Point, Bell's Headland and Point Addis consist chiefly of silty marls with white calcareous nodules but no other distinctive features. The thickness at these localities is 42, 26 and 33 ft. respectively.

No exposures of the Puebla Formation are known west of Point Addis.

The contact of the Puebla Formation with the Jan Juc Formation has been described. Its contact with the next succeeding Tertiary beds is not exposed in the area examined.

Zeally Limestone Member. The limestone (calcarenite) which forms the cliffs between Bird Rock and the mouth of Spring Creek are named the Zeally Limestone Member of the Puebla Formation. Specifically it is defined as Section 17 above the base of BJ.1 which is the same stratigraphical interval as Section 18, T.8/T.5. The thickness of both these sections is 54 ft. Calcarenites and clayey marls which form the low cliffs at Point Danger are also part of this Member though detailed correlation with the type section is not possible.

Details of the lithology are given in the description of Sections 17 and 18 and relationship to adjacent formations is discussed in pp. 100-102.

Zeally is the name of the Bay immediately north of Point Danger; Point Danger itself is named Zealey Point on the Admiralty charts. No other suitable name is available along the short strip of coast where the Member crops out.

Micropalaeontology of the Torquay Group

Foraminifera are present in different degrees of abundance in the rocks comprising the Torquay Group. They are abundant in the beds of the Jan Juc Formation but less common in those of the Puebla Formation.

A distribution chart of species found in the Torquay Bore (Chapman, 1921) in the FB. section (between Fisherman's Steps and Bird Rock) in the BR. section (Bird Rock) and eastward to Section T. (headland south of the mouth of Spring Creek), is given in Table XVI, and it illustrates the striking change in the foraminiferal assemblages of the Janjukian (Upper Eocene) and the Balcombian (Lower Miocene). In this chart the age of the described species is indicated by symbols.

Jan Juc Formation. The only natural section where the Jan Juc Formation is seen in contact with underlying Demon's Bluff Formation is the cliffs at the back of the eastern end of Addiscot Beach (Section 5); here the faunal change is as marked as the lithological one. Numerous tests of *Cyclammina,* the characteristic form of the Demon's Bluff Formation, are present in all samples up to and including B.111 and although *Cyclammina* occurs sporadically throughout the Jan Juc Formation it is not present in the beds immediately overlying B.111; in samples B.105

and B.109, six feet above B.111, typical foraminifera of the Jan Juc Formation, such as *Massilina torquayensis,* are present.

In the type section, the upper lithological boundary* of the Jan Juc Formation coincides with the microfaunal one which is based on the last appearance of one of the ten species listed below. West of Dead Man's Gully, the foraminiferal assemblages are clearly governed by facies changes; the lithology of the beds changes from loosely compacted argillaceous calcarenite at Bird Rock, Fisherman's Steps and Dead Man's Gully to well-cemented calcarenite at Rocky Point, Bell's Headland and Point Addis (Point Addis Member).

Foraminifera are abundant in most of the rock samples from the Jan Juc Formation and the assemblage is dominated by a small group of species which are restricted to the Formation (Crespin, 1950b). These species are:

Bulimina pupula Stache
Dimorphina janjukensis Crespin
Frondicularia victoriae Crespin
Hantkenina alabamensis Cushman, subsp., *compressa* Parr
Massilina torquayensis (Chapman)
Quinqueloculina ornithopetra Crespin
Quinqueloculina singletoni Crespin
†*Sherbornina atkinsoni* Chapman
Vaginulinopsis gippslandicus (Chapman and Crespin)
Victoriella plecte (Chapman)

Another characteristic species, *Lamarckina glencoensis* Chapman and Crespin, is found also in the lower part of the Puebla Formation.

In a westerly direction from Bird Rock Cliff, the type locality for the Jan Juc Formation, to Point Addis (Point Addis Limestone Member), the lithology becomes more calcareous. Some of the characteristic species listed above disappear but *Victoriella plecte* persists. *Sherbornina atkinsoni* is also commonly present, but at Point Addis it seems to be replaced by a genus with affinities to the Middle Eocene genus *Eoannularia*‡ of Cole and Bermudez (1944) and with the genus *Annulopatellina* of Parr and Collins (1930). This form is also present in the Upper Eocene beds at Johanna River. *Hantkenina alabamensis* subsp. *compressa* is restricted to a very narrow band at the top of the Jan Juc Formation in the Bird Rock section (Crespin, 1952).

Glaessner (1951) shows *Hantkenina alabamensis, Victoriella plecte* and (doubtfully) *Sherbornina* as occurring in and characteristic of three separate zones in the Victorian Tertiary sequence. As indicated above and as stated by the authors in earlier notes (Crespin, 1952a; Raggatt, 1952) *Hantkenina* and *Victoriella* occur together at Brown's Creek and Bird Rock. *Sherbonina* is commonly associated with *Victoriella* at Bird Rock.

A distribution chart of selected foraminifera from Bell's Headland and Bird Rock cliff is shown in Fig. 8.

Associated with the above species are numerous small species, several of which persist throughout the Formation. Some of these were described by Parr from

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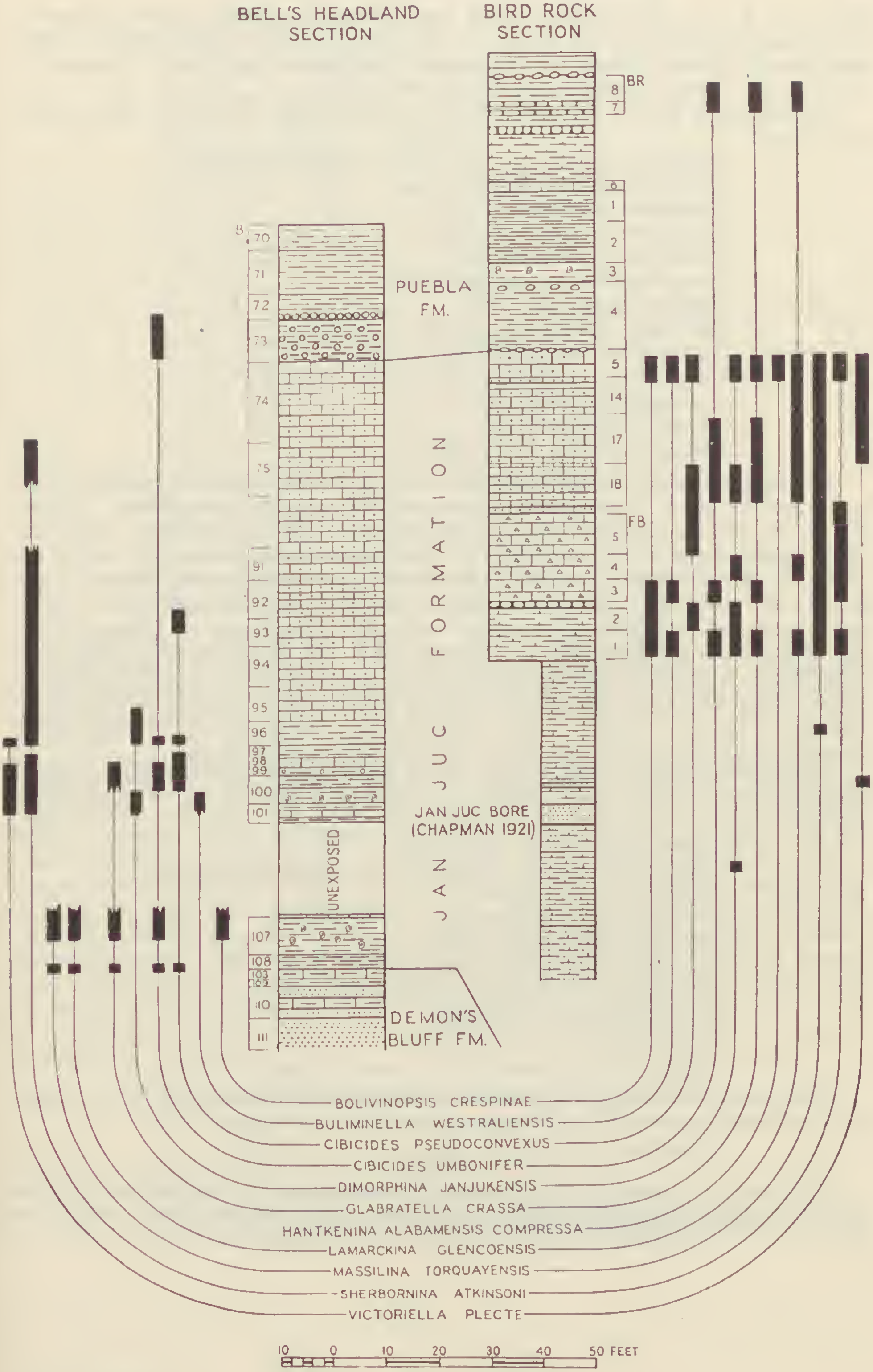
*See comment, p. 137.

†Professor A. Wood (oral communication) considers the genus *Sherbornina* of Chapman to be a *Cycloloculina,* a genus which is characteristic of the Eocene in Europe.

‡Since this paper was read, Miss M. Wade (1955) has given this form the new generic name of *Crespinina.* It was described from Eocene deposits at Kingscote, Kangaroo Island, South Australia.



B M R April, 1954

Fig. 8.—Distribution Chart of selected foraminifera from Bell's Headland and Bird Rock Cliff.

the Upper Eocene of the King's Park Bore, Perth, Western Australia, some by Finlay and Dorreen from the Upper Eocene of New Zealand, and some by Cushman, Bandy, Howe, Nuttall and others from the Eocene and Lower Oligocene of America and Europe. Several new species are present.

The following species were described by Parr (1938) from the King's Park Bore, Perth:

Alabamina obtusa (B. & H.) var. *westraliensis* Parr
Angulogerina subangularis Parr
Anomalina perthensis Parr
Anomalina westraliensis Parr
Bolivinopsis crespinae Parr
Ceratobulimina westraliensis Parr
Cibicides umbonifer Parr
Cibicides pseudoconvexus Parr
Globorotalia chapmani Parr
Guembelina venezuelana Nuttall var. *rugosa* Parr
Heronallenia pusilla Parr
Lagena perthensis Parr
Pseudoglandulina clarkei Parr

Despite the evidence of the above species and the association at Johanna River of *Victoriella plecte*, *Lamarckina glencoensis*,* *Dimorphina janjukensis*, *Frondicularia victoriae* and *Vaginulinopsis gippslandicus* with *Hantkenina*, Glaessner (1953) casts doubt on the record of *H. alabamensis* subsp. *compressa* in the top of the Jan Juc Formation at Bird Rock, on the grounds of faunal differences and absence of "other restricted species usually associated with" *Hantkenina*. A close comparison has been made of species found with *Hantkenina* at Johanna River and Brown's Creek with those in sample BR.5 and below at Bird Rock. The resemblance is striking. Amongst these forms are several undescribed species of *Angulogerina* and a new species of *Cibicides* which occurs not only in the Eocene deposits at Christie's Beach, Port Noarlunga, and Maslin Beach, Aldinga, South Australia, but also in south-western Victoria and at Bird Rock.

Species described by Finlay (1939, 1947) and Dorreen (1948) from the Upper Eocene of New Zealand and present in sediments of the Jan Juc Formation are as follows:

Asterigerina cyclops (Dorreen)
Cibicides perforatus (Karrer) var. *notocenicus* Dorreen
Cibicides vortex Dorreen
Glabratella crassa Dorreen
Globigerinoides index Finlay
Gyroidina scrobriculata Finlay
Planorbulina macphersoni Finlay
Rotorbinella finlayi Dorreen
Sigmoidella bortonica Finlay
Sigmomorphina haeusleri Parr and Collins

American and European species described from the Eocene and Lower Oligocene and found in the Jan Juc Formation include the following:

Cassidulina alabamensis Bandy

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*The species of *Lamarckina* which occurs at Johanna River is *L. novozealandica* Dorreen not *L. glencoensis* Chapman and Crespin as determined by I.C. However, further study of the specimens from Bird Rock shows that both species are present there.

Cassidulina armosa Bandy
Cibicides perlucida Nuttall
Cornuspira byramensis Cushman
Dentalina jacksonensis (Cushman and Applin)
Discorbis assulatus Cushman
Dorothia subglabra (Gümbel)
Epistomina eocenica Cushman and Hanna
Glabratella petalifera (Howe)
Globigerina eocenica Terquem
Globigerina mexicana Cushman
Globigerina ouatchitensis Howe
Guembelina multicellaris Hussey
Gyroidina soldanii (D'Orb) var. *octocamerata* Cushman and Hanna
Hantkenina alabamensis Cushman
Heronallenia vicksburgensis Cushman
Lagena mississippiensis Cushman and Todd
Lagena scarenensis Hantken var. *glabrata* Selli
Nonionella hantkeni (Cushman and Applin)
Robertina ovigera (Terquem)
Robertina wilcoxensis Cushman and Ponton
Robulus alabamensis Cushman
Sigmoidella plummerae Cushman and Ozawa
Stomatorbina torrei (Cushman and Bermudez)
Tubulogenerina vicksburgensis Cushman
Virgulina dibollensis Cushman and Applin

Globigerina pseudobulloides and *G. triloculinoides*, which occur in many samples, were described by Mrs. Plummer (1926) from the Midway (Palaeocene to Lower Eocene) of Texas. Many new species are present and many other specimens show close relationships with species described from the Eocene outside Australia.

Associated with the species listed above, and especially with the eleven characteristic species, are certain species described from the Miocene beds of Australia (Heron-Allen and Earland, 1924; Chapman, 1910; Chapman, Parr and Collins, 1934; Cushman, 1936). Cushman (1933) in describing new species from the Lower Oligocene of Mississippi, remarked that "they show a very close relationship to the foraminifera of the Indo-Pacific, particularly to that of the Miocene of Australia". Included in this comment are *Angulogerina vicksburgensis* which is indistinguishable from *A. australe* (*Uvigerina canariensis* var. *australe*) (Heron-Allen and Earland, 1924) and *Heronallenia vicksburgensis* which is closely related to *H. wilsoni* described by Heron-Allen and Earland (1922) from Recent seas but which is characteristic of Miocene assemblages in Australia.

Species in the Upper Eocene assemblage and described from the Miocene of Australia are as follows:

Alabamina tenuimarginata (Chapman, Parr and Collins)
Alabamina tuberculata var. *australiensis* (Chapman, Parr and Collins)
Astrononion australe Cushman
Carpentaria rotaliformis Chapman and Crespin
Clavulinoides szaboi (Hantken) var. *victoriensis* Cushman
Discorbis margaritiferus (Heron-Allen and Earland)

Eponoides scabriculus (Chapman)
Frondicularia lorifera Chapman
Gaudryina (*Pseudogaudryina*) *crespinae* Cushman
Guttulina (*Sigmoidina*) *silvestrii* Cushman and Ozawa
Hauerina tateana (Howchin)
Sigmoilina chapmani Cushman
Sigmoilina victoriensis Cushman

Puebla Formation. Foraminifera are not as common in the argillaceous sediments which comprise the Puebla Formation as in the more calcareous beds of the underlying Jan Juc Formation. Two assemblages of species are present within the Formation. No characteristic species are present in the lower portion of the Formation which includes approximately 47 ft. of sediments directly overlying the Jan Juc Formation. A few species described from the Upper Eocene have been identified together with one—*Lamarckina glencoensis*—which is otherwise a characteristic species of the Jan Juc Formation. This species was found in sample BR.8. A few Miocene species are associated with these forms.

The Upper Eocene forms include:

Bolivina victoriensis Cushman
Cassidulina armosa Bandy
Cibicides umbonifer Parr
Glabratella crassa Dorreen
Lamarckina glencoensis Chapman and Crespin

The Miocene species include:

Clavulinoides szaboi (Hantken) var. *victoriensis* Cushman
Eponides scabriculus (Chapman)
Reussella pulchra Cushman
Reussella spinulosa (d'Orb.)
Sigmoilina victoriensis Cushman

In sample BR.9, which is 40 ft. stratigraphically higher than BR.8 in Section 7, and in BR.11 and BR.12, still higher in the section, the typical Lower Miocene "Balcombian" species *Cibicides victoriensis* and *Operculina victoriensis* make their first appearance.

The beds of the Zeally Limestone Member contain a characteristic assemblage of species which has been described chiefly from the *Lepidocyclina*-bearing beds and their equivalent in Victoria. The species include:

Calcarina verriculata (Howchin and Parr)
Crespinella umbonifera (Howchin and Parr)
Elphidium howchini Cushman
Elphidium parri Cushman
Gypsina howchini Chapman
Planorbulinella inaequilateralis (Heron-Allen and Earland)
Planorbulinella plana (Heron-Allen and Earland)
Operculina victoriensis Chapman and Parr

Time Rock Units

"Anglesean Stage" (*Pre-Janjukian*)

The discussion on page 111 shows that by definition and usage three interpretations may be given to the term "Anglesean Stage", namely, as the stratigraphical interval represented by:

(a) the Anglesea Member;
(b) the Demon's Bluff Formation;
(c) the Demon's Bluff Formation, the Boonah Sandstone and the Eastern View Coal Measures.

No fossils of age significance are known to occur in the Anglesea Member, or the beds which immediately overlie it; moreover, it rests upon unfossiliferous sediments. Similar remarks apply to the Demon's Bluff Formation except that the age of the beds which overlie it can be closely determined. It would be most unusual to adopt an interpretation such as (c) because many of the beds are non-marine and the coal measures rest upon Jurassic sediments.

Therefore, strictly, none of the interpretations is satisfactory; however, because the name is in the literature it was thought that it might be retained if the stratigraphic interval represented by any one of them could be accurately defined and were, in fact, of Stage rank. Obviously, this cannot be done on the basis of evidence available in the type areas.

It appeared probable that the relationship of the "Anglesean" to contemporaneous and older Tertiary marine sediments could be established by examination of the coastal sections at Brown's Creek and Dilwyn Bay. (Brown's Creek, 9 miles north-west of Cape Otway, is 42 miles south-west of Eastern View, the most westerly locality described in this paper.)

C. A. Wilkinson, in his report (1865) to the Director of the Geological Survey of Victoria, gave a very good account of the Tertiary Sections exposed between Cape Otway and the Gellibrand River. The only sections to which he made no specific reference are those between Johanna River and Rotten Point (Brown's Creek is between these two localities). His description of sections between Castle Cove and Cape Otway have not been improved upon and from the field man's point of view all his notes are useful. Wilkinson commented upon the similarity of certain "dark, almost black" beds with the beds exposed east of Point Addis (Demon's Bluff). Writing about these beds he states: ". . . wherever you examine them numerous small branching markings like algae are present".

George Baker (1943, 1944, 1950, 1953) has given detailed descriptions of the rocks exposed from Moonlight Head westwards. Section 25 is compiled from his descriptions and figures.

Fossils from the grit 35 ft. above the base of the Pebble Point Formation were described by Teichert (1943) and Singleton (1943).

From an examination of the nautiloids Teichert (p. 258) concluded that the rocks "might even be as old as Upper Cretaceous but since we are apparently concerned with the basal part of a continuous sequence which passes upwards into sediments of Miocene age and since the genus *Nautilus* is not known from strata of pre-Tertiary age, an Eocene age for the nautiloid beds seems to be the most likely assumption".

From an examination of the mollusca Singleton (p. 277) concluded: " . . . they may be tentatively referred to the Lower Eocene with a possibility that they may be as old as Paleocene".

The conclusions of Glaessner and Parr (in Baker, 1943) based on determination of the foraminifera were not inconsistent with those reached by the other authors.

Glaessner (1947) examined fossil Crustacea from the Pebble Point Formation and Rivernook Member, stated that they were not of much value for precise determination of age, but commented on their similarity.

SECTION 25

Lower Part of Section of Tertiary beds between Moonlight Head and Gellibrand River (after Baker)

			—	Sandy clays and ironstone.
Wangeripp Group	Dilwyn Clay	Princetown Member	40 ft.	Dark grey to black sandy clays with markings resembling "algal" remains, and *Cyclammina.*
			35 ft.	Unfossiliferous friable red and yellow ferruginous sandstone.
			60 ft.	Clay to shale, in part bituminous. Some polyzoal remains and "algal" markings.
			4/5 ft.	*Trochocyathus* bed. Sandstone with abundant corals, mollusca (*Voluta* and *Dentalium*) and shark's teeth.
			40 ft.	Carbonaceous clay, yellow to grey on weathered surfaces; black when wet.
			5 ft.	*Turritella* bed. Sandstone.
			250 ft.	Carbonaceous clays; abundant copiapite in places; structures resembling "algal" remains.
		Rivernook Member	20 ft.	Glauconitic clay (gritty mudstone); Glaessner (1947).
			500 ft.	Carbonaceous clays, etc. (includes hard ferruginous sandstone with echinoids and pelecypods)—(about middle according to Baker 1943, Fig. 2, p. 243).
	Pebble Point Formation		15 ft.	Ferruginous sandy beds with minor beds of clay.
			—	Fossiliferous grit with ferruginous/argillaceous cement.
			35 ft.	Friable sandy ironstone with bands of grit and veins of limonite.
			—	Jurassic.

In 1947 Teichert described a genus *Deltoidonautilus* from the Clifton Formation (higher in the section than the Princetown Member) and referred to it in the following terms: "No representative of this genus appears ever to have been found in beds younger than Eocene, and, wherever the exact place in the Eocene is known, the species occur in the lower and middle part of that Series".

The palaeontological evidence cited above together with that discussed by Baker (1953) leaves little room for doubt that the fossil bed in the Pebble Point Formation is of Palaeocene Age. It is possible that the Dilwyn Clay up to and including the Rivernook Member may also be Palaeocene. The Dilwyn Clay above the Rivernook Member is clearly not younger than Eocene and may be Lower Eocene. Baker (1953) considers that the Princetown Member at the top of the Dilwyn Clay is Lower Eocene.

Reeves and Evans (1949) measured sections in this locality and concluded that some of the beds were thinner than represented by Baker. Their observations are summarized in Section 26.

Though Chapman (1904) had recorded *Cyclammina* in beds at Brown's Creek lithologically similar to those at Dilwyn Bay, there is no reference to this foraminifer in any later papers about the district. Baker (1953) confirms that Parr did not find *Cyclammina* in any of the material collected by him and it was not present in the samples examined by Miss Crespin for Reeves and Evans.

Parr (1947) described *Hantkenina alabamensis* subsp. *compressa* from Brown's Creek in beds lithologically different from those referred to by Chapman (1904). This genus also was not identified by Parr in the material collected by Baker.

SECTION 26

Group	Formation	Thickness	Description
Wangeripp Group	Dilwyn Clay	100 ft.	Grey and yellowish brown sands overlying ferruginous gravel.
		55 ft.	Chocolate clays with natrojarosite.
		1 ft.	*Trochocyathus* beds.
		50 ft.	Chocolate clays, etc.
		1 ft.	Sandstone with *Turritella.*
		100 ft.	Chocolate clays.
	Pebble Point Formation	90/100 ft.	Ferruginous grits and ironstones.
		15 ft.	Carbonaceous clay with pyrite (exposed at sea-level at Point Margaret).
		—	Jurassic.

The apparent absence of *Cyclammina* and *Hantkenina* from the beds exposed west of Moonlight Head has been investigated by the authors as also have the occurrences at Brown's Creek. The results were summarized in an earlier paper (Raggatt and Crespin, 1952) and are set out hereunder.

On the south-eastern side of Dilwyn Bay (8 miles west of Johanna River) the following section—Section 27—is exposed in the sea cliffs.

SECTION 27

	Thickness			
	ft.	in.		
Dilwyn Clay (Lower Part)	100	–	Some slumping, partly estimated.	Purplish-grey, sandy siltstone.
	70	–	To top of main cliff.	
Pebble Point Formation	27	–	Brown, fine sandstone with lenses of coarse quartz sandstone; concretions 1 in. in diameter and up to 6 in. in length.	
	1	6	Lenticular, shelly fine conglomerate.	
	40	–	Fine conglomerate to coarse, brown sandstone.	
	6	–	Brown sandstone irregularly cemented (ferruginous).	
	50	–	Fine conglomerate to coarse sandstone alternating with black to purplish-brown, fine sandstone, clayey in places.	

This section is illustrated in Baker (1950, Plate II, fig. B) in which the siltstones, 70 ft. thick, can be identified as a light band. The "shelly, fine conglomerate" is the same as Baker's "fossiliferous grit".

The siltstones at the top of the Section (the uppermost 30 ft.) contain *Ammodiscus* sp. (small), *Arenobulimina* sp., *Cyclammina rotundata* Chapman and Crespin, *Cyclammina* sp. (small), *Cibicides* cf. *umbonifer* Parr, *Guttulina irregularis* (d'Orb.). *Cyclammina* is plentiful and can be recognized easliy by eye.

Approximately at the same time as the authors discovered *Cyclammina* at this locality Baker (1953) also found it (near the mouth of the Gellibrand River) in the Princetown Member; i.e. at the top of the Dilwyn Clay.

Between Rotten Point and the mouth of Johanna River the following section—Section 28—is exposed.

SECTION 28

	Thickness		
	ft.	in.	
Exposed in cliffs east of mouth of Johanna River	–	–	Dune sand.
	27	–	Shelly silty limestone.
	1	3	Limestone.
	1	–	Silty limestone.
Exposed in gullies between mouth of Brown's Creek and mouth of Johanna River.	18	–	Well-bedded, pebbly brown sandstone.
	4	–	Grey, micaceous, sandy clay.
	12	–	Alternating light and dark grey clayey marl.
	62	–	Light grey to black shelly clayey marl.
	9	–	Glauconitic, shelly sand with *Notostrea* (abundant in upper 5 ft.) and *Hantkenina*.
	25	–	Grey to dark brown clay with abundant shelly fossils.
	30	–	Estimated; outcrops obscured by dune sand.
Exposed in wash-out above headland between Rotten Point and Brown's Creek.	15	–	Medium to coarse brown sandstone.
	15	–	Pale purple siltstone at base overlain by brown sandstone with thin lenses of light grey clay.
	41	–	Pale purple, silty sandstone.
	5	–	Purple to black, silty sandstone. Quartz pebbles up to 1½ in. in diameter in lower foot.
	2	–	Grey to purplish-brown shale with *Cyclammina*.
	2	–	Pale purple, silty sandstone with lenticular, medium to coarse sandstone. Platey, ferruginous layers.
		6/12	Quartz conglomerate; pebbles ¼ to ½ in. in diameter.
	44	–	Medium to coarse, loosely cemented yellow to brown sandstone.
	40	–	Light grey, silty sandstone; white quartz pebbles ½ in. to 1 in. in diameter.
		6/12	Black sandy siltstone.
		–	Arkosic sandstone (Jurassic).
	354	9	

This section shows the relationship of the beds with *Cyclammina*, described by Chapman (1904), to those with *Hantkenina*, referred to by Parr (1947). Both of these foraminifera have been identified by Crespin in samples collected from the section by Raggatt. The typical Jan Juc Formation foraminifera *Victoriella plecte* and *Lamarckina glencoensis** occur with *Hantkenina* at Brown's Creek.

In addition to *Hantkenina* the beds contain a rich foraminiferal assemblage which is characteristically Eocene. For example, the silty limestone at the top of the section contains:

Anomalina perthensis Parr
Angulogerina subangularis Parr
Bolivinopsis crespinae Parr
Buliminella westraliensis Parr
Cibicides pseudoconvexus Parr
Discorbis assulatus Cushman
Genus aff. *Eoannularia*
Globigerina mexicana Cushman
Globigerina triloculinoides Plummer

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*See footnote p. 128.

Heronallenia pusilla Parr
Guembelina venezuelana Nuttall var. *rugosa* Parr
Lagena terrilli Parr
Pseudobulimina glaessneri Howe and Roberts

Also present are many undescribed species of *Angulogerina* and *Cibicides* which have been noted by Crespin in beds of Eocene age at Christie's Beach, Port Noarlunga, and Maslin Beach, Aldinga, South Australia. These new species are also present at Bird Rock.

Some of the species listed above were identified by Parr in the King's Park Bore, Perth, and regarded by him—at the suggestion of one of us (I.C.)—(see Parr, 1938, p. 70) as Upper Eocene; some have been identified by Cushman and others from the Eocene of America.

If the Section at Brown's Creek (No. 28) is compared with that near Dilwyn Bay (No. 25) it will be seen that the unfossiliferus sandstones at the base of the Tertiary sequence at Brown's Creek are the equivalents of Baker's Pebble Point Formation which contains a bed with Palaeocene marine fauna. Baker (1950, p. 20) has in fact identified the Pebble Point Formation as far east as Moonlight Head (6 miles west of Johanna River), and has noted that east of Point Lucton it is unfossiliferous. At Brown's Creek above the sandstone the sequence is (i) silts with *Cyclammina,* (ii) glauconitic sands and clays with *Hantkenina,* (iii) silty limestone with Eocene foraminifera.

Comparing the Sections at Brown's Creek and Dilwyn Bay with that in the Torquay-Eastern View district there is little doubt—

(i) that the Pebble Point Formation can be correlated with the Eastern View Coal Measures and the Boonah Sandstone, or the Boonah Sandstone alone (the Coal Measures being absent or represented by the carbonaceous sands or clay at the base of the Pebble Point Formation).

Reeves and Evans independently reached a similar conclusion in 1949; they wrote: "the grits, clays and lignite beds at the base of the Anglesean may be correlated with the clays and pebbly grits exposed north-west of Moonlight Head and at Castle Cove".

(ii) that the Demon's Bluff Formation, or part of it, can be correlated with the siltstones (some with *Cyclammina*) at Brown's Creek and Dilwyn Bay.

To a large extent these suggested correlations are based on lithology, and lithogenesis. In considering their value for the purposes of age determination, it is necessary to recognize that formation boundaries may transgress time boundaries. The correlations assume also that beds of the same lithology were deposited approximately synchronously in marine and freshwater environments at different localities (e.g. Pebble Point Formation and Boonah Sandstone). The palaeogeography of the lower Tertiary in southern Victoria suggests that synchronous deposition in marine and freshwater environments occurred over wide areas.

It needs to be borne in mind also that *Hantkenina* has not so far been found in the Princetown area and that the fossils typical of horizons in the Dilwyn Clay and Pebble Point Formation have not been found east of the type localities for those formations. For these reasons the age of the beds below those with *Hantkenina* at Johanna River and the age of the beds above the fossil bed in the Pebble Point Formation cannot be stated with certainty. Also, of course, close correlation between the beds at these two localities is difficult.

On the basis of palaeontological evidence there seems little doubt that—

1. (1) The Jan Juc Formation with *Hantkenina* is of Upper Eocene age.
2. (2) The Pebble Point Formation (and, therefore, approximately the beds with which it is correlated) are of Palaeocene age.
3. (3) The lower part of the Dilwyn Clay is not younger than Lower Eocene and may be in part Palaeocene.

These conclusions do not allow the time interval represented by the Demon's Bluff Formation being determined within narrow limits. There is little doubt it is older than Upper Eocene but it may represent the whole of the Middle and Lower Eocene and, if the lower part of the Dilwyn Clay is Palaeocene, part of the Palaeocene as well.

From this discussion it is concluded that none of the possible uses of "Anglesean Stage" referred to on p. 131 is satisfactory; (a) and (b) because the stratigraphic interval cannot be accurately defined, and (c) because it represents far too great a time interval. The term should, therefore, be discarded and new pre-Janjukian stages defined. The information available does not allow of this being done immediately.

Janjukian Stage

The type section of the Janjukian Stage as defined by Hall and Pritchard (1902) and by Singleton (1941) is exposed between the mouth of Spring Creek (Jan Juc Point) and Rocky Point. As defined by these authors it is, in fact, the stratigraphical interval represented by the Torquay Group of this paper.

The type section of the "Balcombian Stage" at Balcombe Bay, Mornington, is a very unsatisfactory one, and as has been briefly discussed earlier in this paper there has been disagreement about its position relative to the Janjukian. However, it has been generally accepted for some time now that the Balcombian overlies the Janjukian but the precise relationship has never been determined. Singleton, in fact, considered that the Batesfordian lies between the Janjukian and the Balcombian. This conclusion is not supported by the work of one of us on samples from numerous bores and a deep shaft in East Gippsland (I.C., 1941, 1943) which suggests that beds with *Lepidocyclina* (Batesfordian) lie within beds with a Balcombian fauna. This is suggested also by results obtained from determination of the foraminifera in the beds above and below the Batesford limestone.

The earlier discussion in this paper, and the diagrams illustrating correlation and distribution of foraminifera in the Torquay Group show that the fauna of its upper part (Puebla Formation) is typically "Balcombian". (Table 14 and Fig. 5.) As, by definition, it is part of the Janjukian, there seems little doubt that the Janjukian and Balcombian as at present defined overlap each other. It is, therefore, proposed to re-define the Janjukian.

As pointed out on p. 123, in most places the contact between the Jan Juc and Puebla Formations is sharply defined and marks a significant change in conditions of sedimentation which is expressed by change in lithology, marked reduction in fossil content, and in the development of glauconite. Glauconite is very abundant, in the upper part particularly, of the Jan Juc Formation, and scarce in the Puebla Formation. Except in the bottom 18 ft., at Fisherman's Steps and Bird Rock, glauconite is, in fact, virtually absent from the Puebla Formation.

The analysis of the microfauna of the Torquay Group shows that the Jan Juc Formation contains ten species of foraminifera, which do not occur in overlying beds:

Bulimina pupula Stache
Dimorphina janjukensis Crespin
Frondicularia victoriae Crespin
Hantkenina alabamensis (Cushman) subsp. *compressa* Parr
Massilina torquayensis Chapman
Quinqueloculina singletoni Crespin
Quinqueloculina ornithopetra Crespin
Vaginulinopsis gippslandicus (Chapman and Crespin)
Victoriella plecte (Chapman)

The following smaller species are also restricted to the Formation:

Alabamina obtusa (B. and H.) var. *westraliensis* Parr
Bolivinopsis crespinae Parr
Cibicides pseudoconvexus Parr
Discorbis assulatus Cushman
Glabratella sp. 1
Lagena perthensis Parr
Lagena sp. 1
Nonionella hantkeni (Cushman and Applin)

It may be noted that, as pointed out on page 80 of this paper, Tate and Dennant (1895) had suggested that two separate faunas might be represented in the Bird Rock cliffs. They referred to mega-fossils and it will be of considerable interest to see whether the conclusions reached by the authors are supported by other workers whose main interest is in the larger fossils.

For the reason that the Formation contains so many foraminifera of restricted range, including a subspecies of *Hantkenina alabamensis* (a species known to have a restricted range elsewhere) and because also the Formation clearly represents a significant part of geological time, characterized by conditions differing significantly from that before and after its deposition, *the Janjukian Stage is defined as the stratigraphical interval represented by the Jan Juc Formation, and characterized by the microfaunal assemblages listed above.*

The change from pre-Janjukian to Janjukian conditions of sedimentation as has been described (pp. 123, 136) was most marked; all criteria which could be used to define the base of the Janjukian would lead to the same conclusion. In determining the boundary between the Janjukian and the "Balcombian" it can be argued that, because at Bird Rock and Fisherman's Steps sediments up to 18 ft. above the top of the Jan Juc Formation have some lithological features (ovoid pellets and glauconite) in common with the Formation, the Janjukian Stage might be defined in terms somewhat different from those used above. This possibility is admitted and it is accepted that there may be differences of opinion as to what criteria should be given the most weight in drawing boundaries which cannot but be arbitrary. In placing the upper limit of the Janjukian at the top of the Jan Juc Formation reliance has been placed mainly on two criteria:

(i) none of the species restricted to the Janjukian as defined herein has been found above the top of the Formation;
(ii) there is no convenient or definable surface higher than the top of the Jan Juc Formation at which a boundary could be drawn.

The evidence available is insufficient to permit re-definition of the Balcombian.

There seems little doubt that the Janjukian Stage as defined above is Upper Eocene in age. According to Grimsdale (1951) *Hantkenina alabamensis* is restricted to the Upper Eocene (Jackson) of the Gulf of Mexico and Carribean areas in America and to the Upper Eocene (Bartonian) of the Middle East. Bronnimann (1950) gives a similar age for the species in the British West Indies and at the same time makes comments on Parr's *H. alabamensis* subsp. *compressa*. *Guembelina multicellaris* was described by Hussey (1949) from the Upper Eocene of Louisiana. Also of importance is the occurrence of *Globigerinoides index*, which occurs with *Hantkenina* and which Finlay described from the Middle Eocene (Bortonian Stage) of New Zealand. Grimsdale records this species from the Upper Eocene of the Gulf of Mexico and Carribean areas and of the Middle East. *"Globigerinella" micra* (*Nonion micrus*) (Cole) (1927) is also a typical Eocene species in the above area. The use of the rapidly moving pelagic foraminifera such as *Hantkenina, Globigerina* and *Globotoralia* in long-range correlations in the Lower Tertiary is becoming of considerable importance where the larger forms are absent.

Amongst the ten species which are so characteristic of the Formation, except for *Hantkenina alabamensis* subsp. *compressa,* probably the most important is *Victoriella plecte*. It is not affected by facies changes. Its recent discovery in north-west Australia in association with the typical Eocene genus *Discocyclina* suggests that it is a reliable index fossil for the Upper Eocene in Australia.

There is room for speculation concerning the age of the beds immediately above the zone of *Hantkenina*. It may be that in southern Victoria, at least, this zone does not represent the absolute top of the Eocene because—

(i) the beds above the *Hantkenina* zone at Johanna River contain a microfauna which is apparently Eocene, and which is familiar to that found at Bird Rock;

(ii) *Lamarckina glencoensis,* which is common in the beds of the Jan Juc Formation, also occurs in the basal beds of the Puebla Formation in the Bird Rock Section.

The presence of beds with an Eocene fauna above the *Hantkenina* zone at Johanna River also leads to the conclusion that the Jan Juc-Puebla contact represents a non-sequence, as indeed it must be if the Puebla Formation is, as the palaeontological evidence suggests, Lower Miocene.

The precise stratigraphical position of the Batesford Limestone (which contains *Lepidocyclina*) in relation to the top of the Jan Juc Formation is not known but it is certainly above it. As the species of *Lepidocyclina* found at Batesford are regarded as Lower Miocene in age (Crespin, 1936, 1953) the beds between the two fossil zones, that is between the *Lepidocyclina* beds and the zone of *Hantkenina* may possibly be Lower Oligocene in age but this possibility is not supported by palaeontological evidence.

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